A SECONDARY ANALYSIS OF ANTHROPOMETRIC DATA FROM THE 1999 NATIONAL FOOD CONSUMPTION SURVEY, USING DIFFERENT GROWTH REFERENCE STANDARDS.

By

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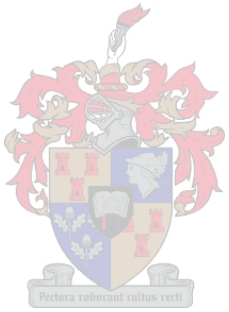

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Declaration

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ABSTRACT

INTRODUCTION: The best known reference standards used to evaluate the growth and development of infants and children are the 1977 National Centre for Health Statistics (NCHS) - , the 2000 Centres for Disease Control and Prevention (CDC) - and the World Health Organization (WHO) (2006). The NCHS reference standards were used to analyse anthropometric data from the 1999 National Food Consumption Survey (NFCS). It was anticipated that using the 2000 CDC and the 2006 WHO reference standards may lead to differences in the previously estimated prevalences of stunting, wasting, underweight, risk of overweight, overweight and obesity in the study population.

AIM: To compare the anthropometric status of children aged 12 - 60 months when using the 1977 NCHS -, the 2000 CDC -, and the 2006 WHO reference standards.

METHODS: A secondary analysis of anthropometric data from the 1999 NFCS was conducted using different reference standards to compare anthropometric status in terms of the prevalences of stunting, wasting, underweight, risk of overweight, overweight and obesity. Relationships between anthropometric status and other variables such as breastfeeding, maternal education level and type of housing were explored.

RESULTS: The prevalences of stunting, obesity and overweight were significantly higher and the prevalence of underweight and wasting were lower when using the 2006 WHO compared to the 1977 NCHS and the 2000 CDC

reference standards. A significant relationship was found between weight-for-height and breastfeeding when using any one of the reference standards and between BMI-for-age and breastfeeding when using the 2006 WHO reference standard. A significant relationship was shown between maternal education level and height-for-age and weight-for-age when using any one of the three reference standards and a significant association was found between weight-for-height and BMI-for-age and the type of housing when using any of the three reference standards.

CONCLUSIONS: The prevalences of stunting and obesity were higher when using the 2006 WHO reference standards compared to the 1977 NCHS and 2000 CDC reference standards. This may be due to the linear growth and rate of weight gain of breastfed infants differing from formula fed infants and the 2006 WHO reference made use of the exclusively and predominantly breastfed infant living under normal healthy conditions as the normative model which is a prescription of how children should not grow and .not an indication of how children are growing. In conclusion, the 2006 WHO reference standard must be the only reference standard used nationally and internationally when assessing the growth and nutritional status of infants and children.

OPSOMMING

INLEIDING: Die mees bekende standaarde wat tans gebruik word is die 1977 NCHS -, 2000 CDC - en die 2006 WHO standaarde. Die 1977 NCHS standaarde was gebruik om antropometriese data van die 1999 National Food Consumption Survey (NFCS) te analiseer. Die verwagting was dat heranalise van die data met behulp van die 2000 CDC en 2006 WHO standaarde mag lei tot verskille in die voorheen bepaalde prevalensie van wanvoeding onder kinders in Suid Afrika.

DOEL: Om die antropometriese status van kinders 12 - 60 maande te vergelyk wanneer die 1977 NCHS, 2000 CDC en 2006 WHO standaarde gebruik word.

METODES: ’n Sekondêre analise van antropometriese data van kinders 12 - 60 maande van die 1999 NFCS was uitgevoer deur gebruik te maak van verskillende standaarde om sodoende die prevalensie van ingekorte groei, uittering, ondergewig, risiko vir oorgewig, oorgewig en obesiteit te bepaal. Moonlike verwantskappe tussen antropometriese data en ander veranderlikes is ondersoek, naamlik borsvoeding, die opvoedingsvlak van die moeder en die tipe woning.

RESULTATE: Die prevalensie van ingekorte groei, oorgewig en obesiteit was beduidend hoër en die prevalensie van ondergewig en uittering was laer met die gebruik van die 2006 WHO standaard in vergelyking met die 1977 NCHS en die 2000 CDC standaarde. ‘n Beduidende verhouding was aangedui tussen gewig-vir-ouderdom en borsvoeding met die gebruik van enige een van die standaarde en tussen LMI-vir-ouderdom en borsvoeding wanneer die 2006 WHO standaard

gebruik word. ‘n Verhouding is ook aangedui tussen die moeder se opvoedingsvlak en lengte-vir-ouderdom en gewig-vir-ouderdom wanneer enige van die standaarde gebruik word. ‘n Verhouding is ook angedui tussen gewig-vir-lengte en LMI-vir-lengte en die tipe woning wanneer enige een van die standaarde gebruik word.

GEVOLGTREKKING: Die prevalensie van ingekorte groei en obesiteit is hoër met die gebruik van die 2006 WHO standaard in vergelyking met die 1977 NCHS en 2000 CDC standaarde. Dit mag wees as gevolg van die groei van babas wat geborsvoed word wat verskil van babas wat formule voeding ontvang en die 2006 WHO groeikaarte se studie populasie wat bestaan uit babas en kinders wat geborsvoed is en sodoende ‘n voorskrif is van hoe kinders moet groei en nie ‘n aanduiding is van hoe hulle huidiglik groei nie. Die 2006 WHO groeikaarte moet die enigste groeikaarte wees wat internasionaal en nasionaal gebruik word om die groei en ontwikkeling van babas en kinders to evalueer.

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LIST OF DEFINITIONS

Z-score: The deviation of an individual's value from the median value of a reference population, divided by the standard deviation of the reference population.[1]

Stunting: Less than minus two standard deviations (< -2 SD) height-for-age.[2]

Underweight: Less than minus two standard deviations (< -2 SD) weight-for-age.[2]

Obese: Greater than plus three standard deviations (> + 3 SD) weight-for-length/height or greater than plus three standard deviations (> + 3 SD) BMI-for-age.[3]

Overweight: Greater than plus two standard deviations (> + 2 SD) weight-for-age or greater than plus two standard deviations (> + 2 SD) weight-for-height or greater than plus two standard deviations (> + 2 SD) BMI-for-age.[2]

Wasted: Less than minus two standard deviations (< - 2 SD) weight-for-height.[2]

Under nutrition: This is the result of food intake that is continuously insufficient to meet dietary energy requirements, poor absorption and/or poor biological use of nutrients consumed. This usually results in loss of body weight.[4]

Over nutrition: This refers to a chronic condition where intake of food is in

excess of dietary energy requirements, resulting in overweight and/or obesity.[4]

A Possibly Problematic weight-for-age

A weight-for-age that needs to be re-evaluated frequently to prevent nutritional disorders

Presence of Breastfeeding categories:

Breastfeeding present, absent or status not known

Education level of the mother categories:

No formal education, primary school education, high school education and tertiary education

Type of dwelling categories:

Brick -, traditional mud -, tin -, plank/wood dwellings or homes built using other materials

LIST OF ABBREVIATIONS

AAP	American Academy of Pediatrics
BMI	Body mass index
BMIZ	BMI-for-age Z-scores
CDC	Centres for Disease Control and Prevention
DOH	Department of Health
EA	Enumerator Area
HAZ	Height-for-age Z-scores
HH	Household
INP	Integrated Nutrition Programme
NFCS	National Food Consumption Survey
NCHS	National Centre for Health statistics
PedNSS	CDC Pediatric Nutrition Surveillance System
RSA	Republic of South Africa
SD	Standard deviation
WAZ	Weight-for-age Z-scores
WHO	World Health Organization
WHZ	Weight-for-height Z-scores
QFFQ	Quantitative Food Frequency Questionnaire

LIST OF TABLES

Table 1.1 A summary of the main differences between the 1977 NCHS, 2000 CDC and 2006 WHO reference standards

Table 2.1 Categorization of the children's anthropometric status using the 2000 CDC reference standard

Table 2.2 Categorization of the children's anthropometric status using the 2006 WHO reference standard

Table 3.1 Percentages of children classified for height-for-age by the 1977 NCHS and the 2006 WHO reference standards

Table 3.2 Percentages of children classified for height-for-age by the 1977 NCHS and the 2000 CDC reference standards

Table 3.3 Percentages of children classified for height-for-age by the 2000 CDC and the 2006 WHO reference standards

Table 3.4 Percentages of children classified for weight-for-age by the 1977 NCHS and the 2006 WHO reference standards

Table 3.5 Percentages of children classified for weight-for-age by the 1977 NCHS and the 2000 CDC reference standards

Table 3.6 Percentages of children classified for weight-for-age by the 2000 CDC and the 2006 WHO reference standards

Table 3.7 Percentages of children classified for weight-for-height by the 1977 NCHS and the 2006 WHO reference standards

Table 3.8 Percentages of children classified for weight-for-height by the 1977

NCHS and the 2000 CDC reference standards

Table 3.9 Percentages of children classified for weight-for-height by the 2000 CDC and the 2006 WHO reference standards

Table 3.10 Percentages of children classified for BMI-for-age by the 2000 CDC and the 2006 WHO reference standards

Table 3.11 Mean HAZ by the 1977 NCHS -, 2000 CDC and the 2006 WHO reference standards according to the presence of breastfeeding

Table 3.12 Mean WAZ by the 1977 NCHS -, 2000 CDC and the 2006 WHO reference standards according to the presence of breastfeeding

Table 3.13 Mean WHZ by the 1977 NCHS -, 2000 CDC and the 2006 WHO reference standards according to the presence of breastfeeding

Table 3.14 Mean BMIZ by the 2000 CDC and the 2006 WHO reference standards according to the presence of breastfeeding

Table 3.15 Mean HAZ by the 1977 NCHS -, 2000 CDC and the 2006 WHO reference standards according to the education level of the mother

Table 3.16 Mean WAZ by the 1977 NCHS -, 2000 CDC and the 2006 WHO reference standards according to the education level of the mother

Table 3.17 Mean WHZ by the 1977 NCHS -, 2000 CDC and the 2006 WHO reference standards according to the education level of the mother

Table 3.18 Mean BMIZ by the 2000 CDC and the 2006 WHO reference standards according to the education level of the mother

Table 3.19 Mean HAZ by the 1977 NCHS -, 2000 CDC and the 2006 WHO reference standards according to the type of dwelling

Table 3.20 Mean WAZ by the 1977 NCHS -, 2000 CDC and the 2006 WHO reference standards according to the type of dwelling

Table 3.21 Mean WHZ by the 1977 NCHS -, 2000 CDC and the 2006 WHO reference standards according to the type of dwelling

Table 3.22 Mean BMIZ by the 2000 CDC and the 2006 WHO reference standards according to the type of dwelling

LIST OF FIGURES

Figure 1.1 Causes of mortality for children under 5 years of age by region

Figure 1.2 UNICEF Conceptual Framework for the Causes of Malnutrition

Figure 3.1 Comparison of the mean HAZ, WAZ, WHZ and BMIZ using the different reference standards in this study

Figure 3.2 Percentage of children aged 12 - 60 months classified for height-for-age by the 1977 NCHS -, 2000 CDC - and the 2006 WHO reference standards

Figure 3.3 Percentage of children aged 12 - 60 months classified for weight-for-age by the 1977 NCHS -, 2000 CDC - and the 2006 WHO reference standards

TABLE OF CONTENTS

		Page
Declaration of authenticity		ii
Abstract		iii
Opsomming		v
Acknowledgements		vii
List of Definitions		viii
List of Abbreviations		x
List of Tables		xi
List of Figures		xiv

CHAPTER 1: INTRODUCTION AND PROBLEM STATEMENT

1.1	Introduction	2
1.2	The Impact of Breastfeeding, Maternal Education Level and Type of Housing on Infant and Child Nutritional Status	4
1.3	The Importance of Anthropometry in the Assessment of Child Growth	10
1.4	Reference Standards	12
1.4.1	The 1977 NCHS reference standard	12
1.4.2	The 2000 CDC reference standard	16
1.4.3	The 2006 WHO reference standard	19
1.5	Motivation for the Study	23

CHAPTER 2: METHODOLOGY

2.1	Research Aims	25
2.1.1	Aim	25
2.1.2	Specific objectives	25
2.2	Hypotheses	26
2.2.1	Null hypotheses	26
2.3	Study Design	27
2.4	Study Population and Sampling	27
2.4.1	Study population	27
2.4.2	Sampling	27
2.4.3	Sample selection and weighting procedures	28
2.5	NFCS Methodology	30
2.5.1	Age and gender determination	30
2.5.2	Weight determination	31
2.5.3	Height determination	31
2.5.3.1	*Children younger than 2 years of age*	31
2.5.3.2	*Children older than 2 years of age*	31
2.6	Methods of Data Processing and Statistical Analysis	32
2.6.1	General	32
2.6.2	Criteria used for the assessment of anthropometric status	33
2.6.3	Methods of analysis of anthropometric data	36
2.7	Ethics	37
2.7.1	Ethics and legal aspects	37

2.7.2 Informed consent and patient confidentiality 38

CHAPTER 3: RESULTS

3.1 Sample Characteristics 40

3.2 Prevalence and Significant Differences between the References 41

3.2.1 Stunting 42

3.2.1.1 *Comparison between the 1977 NCHS - and the 2006 WHO reference standard* 43

3.2.1.2 *Comparison between the 1977 NCHS - and the 2000 CDC reference standard* 44

3.2.1.3 *Comparison between the 2000 CDC - and the 2006 WHO reference standard* 46

3.2.2 Underweight 47

3.2.2.1 *Comparison between the 1977 NCHS - and the 2006 WHO reference standard* 48

3.2.2.2 *Comparison between the 1977 NCHS - and the 2000 CDC reference standard* 49

3.2.2.3 *Comparison between the 2000 CDC - and the 2006 WHO reference standard* 51

3.2.3 Classification of wasting, risk of overweight, overweight and obesity 52

3.2.3.1 *Weight-for-height* 52

3.2.3.2	*BMI-for-age*	59
3.3	Relationships between Anthropometric Status and Other Variables	61
3.3.1	Breastfeeding	61
3.3.1.1	*Height-for-age*	61
3.3.1.2	*Weight-for-age*	62
3.3.1.3	*Weight-for-height*	64
3.3.1.4	*BMI-for-age*	65
3.3.2	Maternal education level	67
3.3.2.1	*Height-for-age*	67
3.3.2.2	*Weight-for-age*	69
3.3.2.3	*Weight-for-height*	71
3.3.2.4	*BMI-for-age*	72
3.3.3	Type of housing	74
3.3.3.1	*Height-for-age*	74
3.3.3.2	*Weight-for-age*	75
3.3.3.3	*Weight-for-height*	77
3.3.3.4	*BMI-for-age*	78

CHAPTER 4: DISCUSSION

4.1	Introduction	81
4.2	Results from this Survey	82
4.2.1	Prevalence of stunting, wasting, underweight, risk of	

	overweight, overweight and obesity	83
4.2.2	Anthropometric status related to other variables	89
4.2.2.1	*Breastfeeding*	89
4.2.2.2	*Maternal education level*	92
4.2.2.3	*Type of dwelling*	94
4.3	Implications of Results for Programmes and Policies	96
4.4	Limitations of the Study	98

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1	Conclusions and Recommendations	100

List of References 105

CHAPTER 1: INTRODUCTION AND STATEMENT OF THE RESEARCH QUESTION

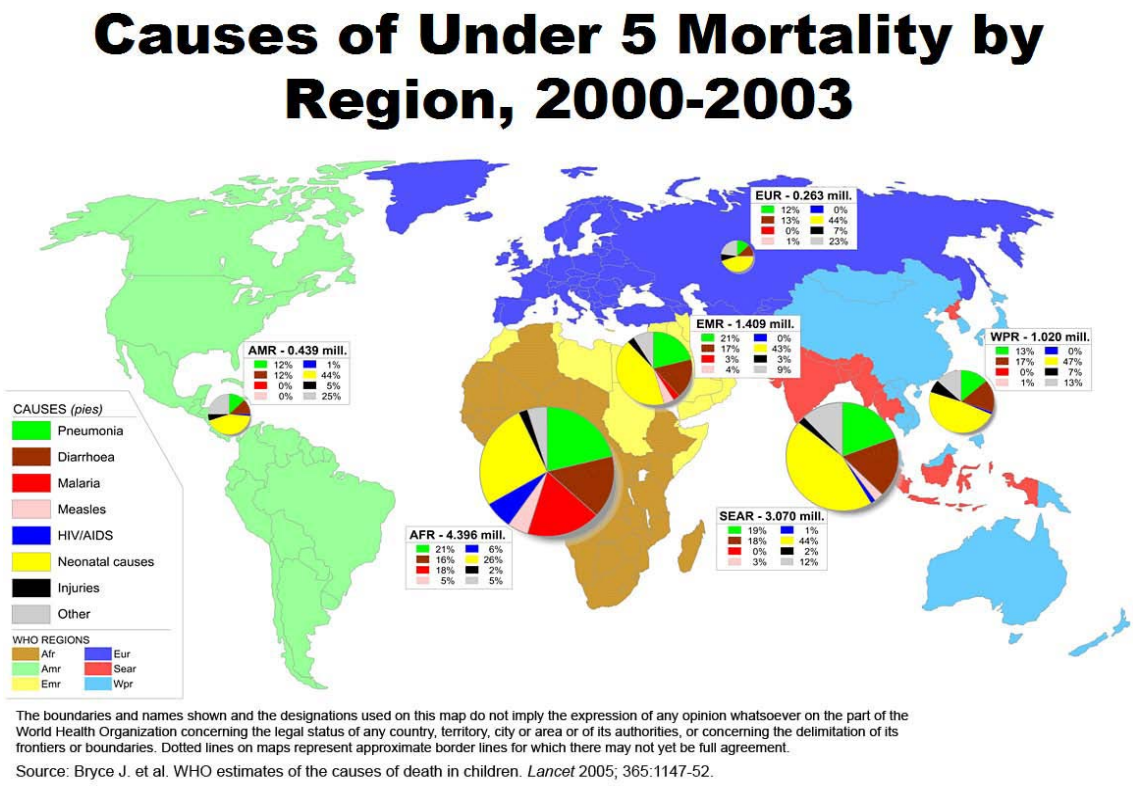
1.1 Introduction

Malnutrition is a major nutritional disorder facing communities globally and especially in Africa. The WHO defines malnutrition as the deficiencies, excesses or imbalances in intake of energy, protein and/or other nutrients. This term then includes both under-nutrition and over-nutrition. The WHO estimates that there are 170 million underweight children worldwide and at least 20 million children under the age of 5 years that are overweight.[5]

Worldwide children seem to become better nourished; between 1990 and 2000 the prevalence of stunting and underweight decreased by 20% and 18% respectively.[6] However, during this period the number of children who are stunted and underweight in sub-Saharan Africa increased. According to the 1999 National Food Consumption Survey (NFCS) nearly one in five children in South Africa was stunted and one in ten children was classified as being underweight. The prevalence of combined overweight and obesity (Body Mass Index $\geq$ equivalent of adult BMI of 25 kg m $^{-2}$) is 17.1%.[7]

Child mortality is also slowing down worldwide, however the World Health Report of 2005 states that the under-five-mortality rate for children of the African region is seven times higher than in the European region. Contributing factors to Africa's lack of progress may be malnutrition, poverty, the destructive influence of HIV/AIDS and exclusion of mothers from health care.[6] According to an article in

the Lancet, the major factors contributing to under-5 child mortality is neonatal causes such as preterm delivery, sepsis and birth asphyxia and pneumonia and in Africa the major contributing factors are pneumonia and diarrhoea. (Figure 1.1) Under nutrition is an underlying cause of 53% of all deaths in children younger than 5 years.[8]



Source: From Reference.[7]

Figure 1.1: Causes of mortality for children under 5 years of age by region

The consequences of malnutrition in childhood can be severe and range from mortality to psychological and intellectual developmental problems. Malnourished children tend to have more diarrhoeal episodes and associated growth faltering

and increased risk for pneumonia. There are also consequences in adulthood that range from stunting, poor reproductive and work performance to increased risk of chronic diseases.[1]

Clearly, there is a need for research in the important field of infant and child growth and factors impacting on growth, especially in the African Region.

1.2 The Impact of Breast-feeding, Maternal Education Level and Type of Housing on Infant and Child Nutritional Status

There are several factors known to impact an individual's nutritional status consequently leading to malnutrition. These are divided into immediate -, underlying - and basic causes. Immediate causes include inadequate dietary intake and disease, underlying causes include insufficient access to food, inadequate maternal and child-care and poor sanitation and inadequate health services. The quantity and quality of actual resources (insufficient knowledge and discrimination) and the potential resources (the woman's status in the community, political, cultural and religious systems) are basic causes. The UNICEF conceptual framework (Figure 1.2) shows the many factors that impact the nutritional status of infants and children.[9]

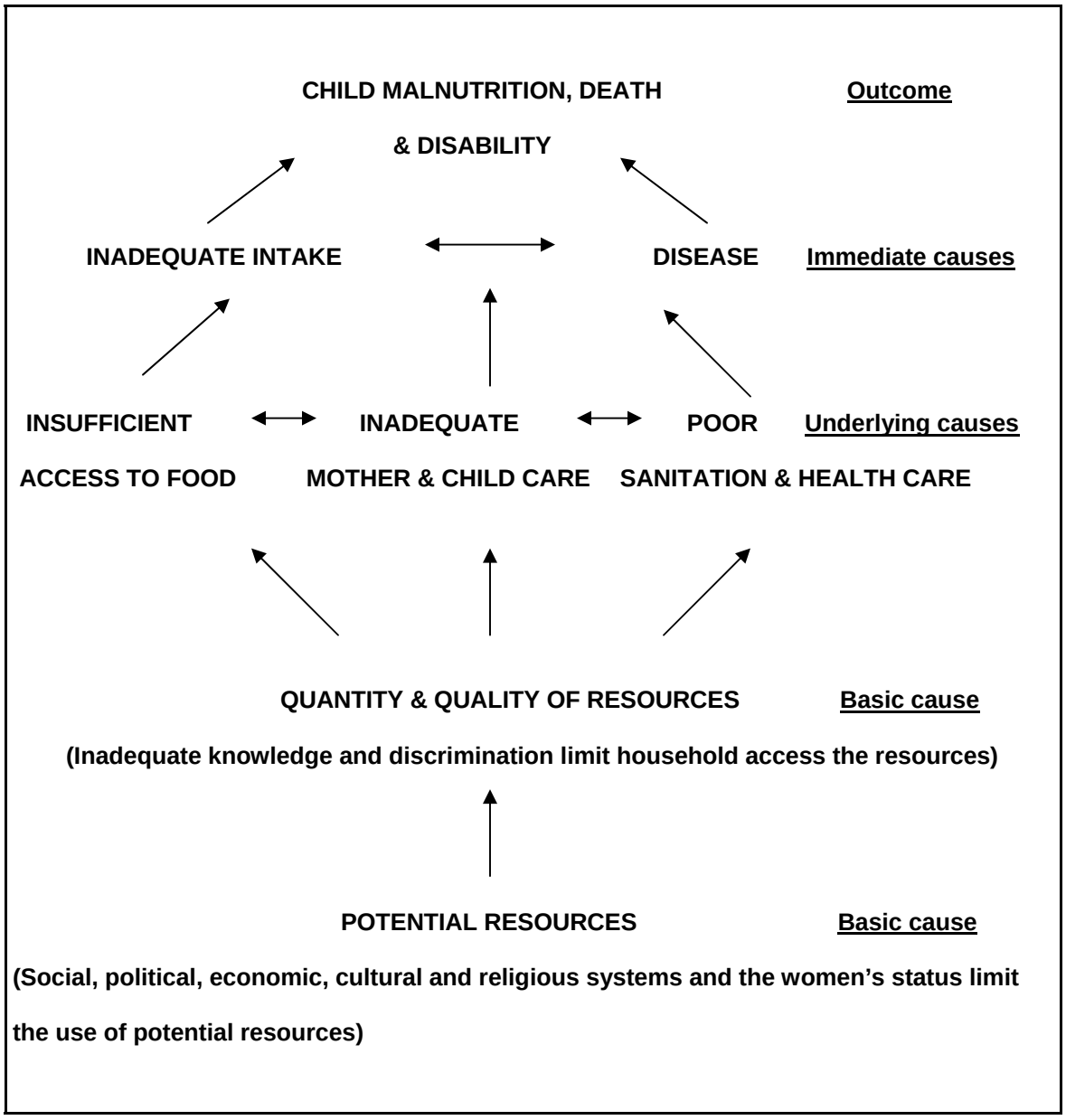


Figure 1.2: UNICEF Conceptual Framework for the Causes of Malnutrition[9]

Adequate dietary intake and consequently breastfeeding is one of these factors influencing infant and child growth. The positive short-term effects of breastfeeding on infant health are well known and include the provision of the necessary nutrients, growth factors and immunological components a normal

healthy infant needs. Breast milk decreases the incidence and/or severity of infections such as bacterial meningitis, bacteraemia, diarrhoea, respiratory tract infection, necrotizing enterocolitis, otitis media, urinary tract infection and late-onset sepsis in preterm infants.[10, 11]

A recent WHO publication states that breastfeeding also has long-term benefits including lowering mean blood pressure and total cholesterol in adulthood, prevention of allergies and decreasing the prevalence of obesity and insulin-dependant diabetes mellitus. However further studies are needed to support the latter hypotheses. Breastfeeding is also associated with increased cognitive development in childhood and positively associated with educational attainment.[10, 11, 12]

The American Academy of Pediatrics (AAP) states that it is not only the infant that benefits from breastfeeding; there are also several advantages for the breastfeeding mother. These include decreased postpartum bleeding, bonding with the infant, lactation amenorrhea, earlier return to pre-pregnancy weight, early involution of the uterus and reduced incidence of ovarian - and breast cancer.

Considering these advantages of breastfeeding and the fact that breastfeeding a child is more economical than artificial feeding, it would be especially beneficial for low income communities and developing countries.[10, 11]

Breastfeeding has an important role to play in South Africa where there is a high prevalence of HIV/AIDS and low income communities. Current evidence favours exclusive breastfeeding for 6 months to prevent mother-to-child HIV transmission for most mothers although individual circumstances should be considered.[13] South Africa faces several obstacles to implementing exclusive breastfeeding. A 1998 demographic and health survey of South Africa found on the WHO Global Data Bank on Breastfeeding and Complementary Feeding states that of a national sample of 4992 women 87% reported as having ever breastfed their under 12 months old children. However the exclusive breastfeeding rate at 4 months was only 10% and 58% of infants less than 12 months of age were receiving food or drink from a bottle.[14] This poses a major problem since bottle feeding is not appropriate in all circumstances and especially not in communities where poverty and poor sanitation is widespread. Mothers living in these conditions do not have the financial means to purchase artificial milk and the water may be infected with micro-organisms that can cause diarrhoea in the child further contributing to growth faltering and child mortality.

With an exclusive breastfeeding rate of only 10% at age 4 months, it is evident there are several factors that influence the initiation and duration of breastfeeding. A recently published study indicates that women who initiate breastfeeding and continue breastfeeding for a longer period of time are more likely to be older and more educated than women who do not.[15] Insufficient prenatal education about breastfeeding, disruptive hospital policies and

practices, early hospital discharge, lack of follow-up care, maternal employment, lack of support, commercial promotion of bottle feeding and misinformation are some of the obstacles listed by the AAP to the initiation and continuation of breastfeeding.[11]

Taking into consideration the several advantages of breastfeeding and the fact that breastfeeding is more likely to be sustained when mothers are educated; education and type of housing are other factors to consider when discussing infant and child nutritional status. According to the 1999 NFCS one out of ten mothers of children of all age groups had no formal education; 25% of mothers had primary school education only, 27% had high school and 8% tertiary level education. One third of the caregivers of the children from this study attained an unknown level of education and they achieved an overall lower education status. The 1999 NFCS also reported that maternal education was associated with a significant reduction in the prevalence of stunting, underweight and wasting in all age groups of children. The study also reported a significant correlation between the level of maternal education and stunting at the national level (Spearman correlation: $r = 0.17$, $p < 0.0001$) and for children living in urban areas ($r = 0.2$; $p < 0.0001$). A significant correlation was also found between the level of maternal education and underweight at the national level ($r = 0.11$; $p < 0.0001$) and for children living in urban areas ($r = 0.20$; $p < 0.0001$). The prevalence of stunting and underweight was highest among mothers with primary school education only. However, improved maternal education level was also associated with an

increased prevalence of a child being overweight especially in urban areas.[16] Parizkova agrees with this stating that the increasing prevalence of childhood obesity is significantly related to the education of children and that of parents who influence food intake and physical activity level. Being educated increases the chances of having improved nutritional knowledge and consequently understanding the importance of healthy eating and exercise.[17] A 1997 study also reported that the degree of food and nutrition knowledge is significantly and positively correlated with socio-economic status, mother's schooling and occupation level, housing conditions (quality and sanitation) and age. Nutrition knowledge was also higher in urban than rural mothers.[18] This is consistent with the comments made in the UN Chronicle which states that education of especially girls, reduces poverty, raises economic productivity, lowers infant and maternal mortality and helps improve nutritional status and health.[19]

The type of houses children live in significantly contributes to their nutritional status. The 1999 NFCS demonstrated that nationally, 67% of the survey population lived in a home constructed with bricks or cement and the remainder lived in dwellings made of tin, plank/wood or other materials. On a national level, the type of dwelling was related to stunting ($r = -0.10$, $p < 0.0001$) and this was also true for children living in urban areas ($r = -0.16$; $p < 0.0001$). The type of dwelling was also related to underweight children living in urban areas (Spearman: $r = -0.12$, $p < 0.001$). The percentage of children classified as stunted and underweight was highest among those living in traditional mud

homes.[16]

1.3 The Importance of Anthropometry in the Assessment of Child Growth

Growth assessment serves as a means of evaluating the health and nutritional status of children. One way is to make use of anthropometric assessments. Other methods include biochemical -, clinical and dietary assessments. Anthropometric assessment has several advantages such as being a non-invasive and inexpensive method to obtain measurements of weight, height and circumferences that can be used as indicators of health, growth and development in infants and children.[20]

At a population level, anthropometry is used to determine the prevalence of under – or over nutrition. It is also used to determine the presence of food and nutritional emergencies, to evaluate the distribution of financial resources in communities and to screen groups at risk of nutritional deficiencies or excesses.[21]

A World Health Organization (WHO) Working Group, established by the WHO Nutrition Unit, summarized the use of anthropometry for individual infants and children as follows:

- The detection of altered growth patterns
- The assessment of the adequacy of intake of milk and milk substitutes
- The determination of the correct age to start introducing complementary foods and assessment of the adequacy of the weaning diet
- Assessment of the impact of illness on growth patterns and the infant's response to treatment and intervention
- Identifying at-risk individuals to be included in nutrition supplemental programs
- The assessment of the response to nutrition education[22]

Anthropometric indices are compared to reference standards or growth charts which are widely used for screening and monitoring of the nutritional status and growth of infants, children, and adolescents.[23] According to a survey done by de Onis *et al*., reference standards are used worldwide in child growth monitoring.[21]

The best known reference standards used to assess the nutritional status, growth and development of infants and children include the growth charts of the National Centre for Health Statistics (NCHS) of 1977, the Centres for Disease Control and Prevention (CDC) of 2000 and the World Health Organization (WHO) of 2006.

1.4 Reference Standards

1.4.1 The 1977 NCHS reference standard

The 1977 NCHS reference standard consist of two age intervals namely birth to 36 months and 2 – 18 years. The Fels Research Institute, Yellow Springs, Ohio supplied the longitudinal data used to construct the birth to 36 months curves. The data used for the 2 – 18 year age group were compiled from data that were collected during 3 cycles lasting several years each and forming part of the National Health Examination Survey (NHES) cycles. The cycles included, NHES Cycle II conducted from 1963 to 1965 for ages 6 – 11 years, NHES Cycle III from 1966 to 1970 for adolescents aged 12 – 17 years and the first US National Health and Nutrition Examination Survey (NHANES I or NHES IV) from 1971 to 1974 that included subjects from the ages of 1 to 75 years. These two data sets were then merged to create the reference referred to as the 1977 NCHS reference standard.[24, 25]

In 1978 the CDC released a normalized version of the 1977 NCHS reference standard. The WHO recommended the use of this reference and it was referred to as the NCHS/WHO, CDC/WHO or NCHS/CDC/WHO growth charts. These curves allowed body measurements to be expressed in terms of standard deviations or Z - scores. It also enabled the description of nutritional status at extremes of the distributions. These curves are similar to the 1977 NCHS reference standard, but not identical.[26]

The 1977 NCHS reference standard has several limitations which have been discussed at length in the literature. These limitations are mostly due to the use of the Fels Research Institute data which were collected between 1929 and 1975. This data set was not representative of the entire US population at the time since the subjects were Caucasian infants from a middle-class society limited to Ohio, that were predominantly formula - fed with milks that are no longer on the market today. Of those infants included in the data set, very few were breastfed for more than 3 months. The growth curves also reflect feeding practices that are no longer recommended by the WHO today. Also the birth weights of the infants from the Fels data did not match the national distribution of birth weights. The subjects were measured at birth, 1 month and then at 3 month intervals from 3 - 12 months and at 6 month intervals from 12 - 36 months, rather than every month. This is an infrequent time period to describe the rapid growth of an infant.[21, 22, 26, 27]

One other major limitation of the NCHS reference standard is that the height-for-age curve consists of two unrelated sets of curves. On the one hand there are the length-based curves from the Fels data for children under 2 years of age (based on supine measurements of length) and on the other there are have the height-based curves from the NCHS data for older children (based on standing height measurements). Consequently there is a disjunction in the height curve at just before and after 24 months of age where the two sets of data merge. This discrepancy is responsible for the change noted at 24 months of age in the mean

height-for-age Z-score; an underestimation of height status when using the Fels length-based curves and an overestimation of height status with the height-based curves from the US sample.[20, 28]

Another limitation is that the NCHS weight-for-age and weight-for-height reference standard has an upward skewness reflecting a substantial level of childhood obesity. This reflects an undesirable characteristic of the sample. This upward skewness may also result in the misclassification of overweight children as having a normal weight.[20, 28] Another concern was the inability of the reference to assess growth at extremes beyond the 5th and 95th percentiles.[26]

Concern was also expressed in the literature that breastfed infants when compared to the NCHS reference standard were growing less than favourably and consequently the reference‘s appropriateness in assessing the growth of breastfed infants were questioned.

A WHO Working Group was established by the WHO Nutrition Unit to evaluate infant growth in preparation for a WHO Expert Committee meeting in 1993 on Physical status: the use and interpretation of anthropometry. The goal of the Working Group was to evaluate infant growth with regard to the appropriate use and interpretation of anthropometry in infants, the identification/development of reference data for anthropometric indicators and other issues. The Working Group were also to examine the growth of breastfed infants living under

favourable conditions who are exclusively breastfed for 4-6 months and are breastfed for the remainder of the year and see whether their growth differ substantially from the NCHS reference standard. A survey was then conducted in 1992 with data sets on breastfed infants. The inclusion criteria for the survey are described elsewhere.[22] The data sets that fulfilled the criteria were from Canada, Denmark, Finland, Sweden, the UK and two sets from the US. The infants included in the study were referred to as the “12 month breastfed pooled data set”. The Z-score patterns of the “12 month breastfed pooled data set” relative to the NCHS reference deviated substantially. The mean weight-for-age, length-for-age and weight-for-height were below the NCHS reference mean. The declines in Z-scores from 5 months onwards may be due to technical problems that occurred in the construction of the NCHS reference standard, but this is unlikely. The declines may also be due to weaning practices, or the physiological effects of breastfeeding or other unknown factors. There was however a return towards the NCHS reference standard for weight-for-age, length-for-age and weight-for-length between 12 - 24 months. Based on this survey the Working Group concluded that infants who are breastfed and living in favourable conditions grew less rapidly and deviated substantially from the NCHS reference standard and that the NCHS reference standard is inadequate and recommends the development of new references. They recommended that the subjects to be included in the reference should practice current health and feeding recommendations i.e. exclusive breastfeeding for 6 months; introduction of complementary feeds at 6 months; continued breastfeeding thereafter, and they

should be from multiple countries.[20, 22, 28]

These discrepancies are significant and may lead health workers to draw inappropriate conclusions about the infant's growth like misdiagnosis of the timing of growth faltering and consequently prematurely introduce complementary foods.[20]

A 1998 study also reported that the average growth of all infants, irrespective of their feeding pattern, was faster than the NCHS reference standard up to ~ 6 months after which their growth became slower than that of the NCHS sample. The study's findings suggested that the infancy portion of the NCHS reference does not sufficiently reflect the growth of either breast - or bottle-fed infants. This may be due to characteristics of the original sample and from inadequate curve-fitting procedures.[29]

1.4.2 The 2000 CDC reference standard

The limitations of the 1977 NCHS reference standard led to its revision and the consequent development of the CDC reference standard which were released in May 2000 for the United States. These charts were developed for infants from birth to 36 months and children and adolescents from age 2 – 20 years using data collected from 1963 to 1994 in the United States in a series of 5 nationally representative surveys (NHES Cycle II and III, NHANES I, II and III). Additional data were added to the infant charts where the national data were not available

or insufficient, namely data from national birth certificates, the Fels Research Institute and the CDC's Pediatric Nutrition Surveillance System (PedNSS). The ethnic distribution of the children included in the database is more representative of the United States at that time. Both formula-fed and breastfed infants are included in the 2000 CDC reference standard for infants, proportional to their distribution in the US population during the time frame of the data collection. In the NHANES II and III, roughly 50% of infants were ever breastfed and approximately 29% were still breastfed at 3 months. Also the 2000 CDC reference standard more closely matches the distribution of birth weights in the US than did the 1977 NCHS charts. Improved statistical techniques were used to create smoothed percentile growth curves. The previously discussed disjunction that was present in the 1977 NCHS reference standard was not in the 2000 CDC reference standard.[26, 27, 30]

The CDC released sex-specific BMI-for-age charts for 2 - 20 years to replace the 1977 NCHS weight-for-stature charts and extended the age range of the charts by 2 years to extend to 20 years of age. The revised charts have added the 3rd and 97th percentiles to each chart to plot children at extremes of the distribution.[26]

The CDC compared the 1977 NCHS - to the 2000 CDC reference standards. With reference to the infant charts, from 12 - 24 months for weight-for-age the 2000 CDC percentiles are generally higher than the 1977 NCHS percentiles. However, the 2000 CDC percentiles are generally lower than the 1977 NCHS

percentiles for length-for-age, especially after 6 months of age. The 2000 CDC percentiles are higher when compared to the 1977 NCHS percentiles for weight-for-height. The study reports that there will be differences in the classifications of children when using the 2000 CDC reference standard to the 1977 NCHS reference standard. These include an increased prevalence of underweight and a decreased prevalence of high weight-for-age and short length-for-age when using the 2000 CDC reference standard.[26]

As mentioned earlier there are substantial differences in the growth patterns of breastfed infants when compared to the NCHS reference standard. A 2003 study was conducted to evaluate the adequacy of the CDC growth charts for assessing the growth of breastfed infants. This study also used data from the pooled sample of 226 healthy breastfed infants to evaluate the differences in growth patterns using the CDC growth curves compared with the NCHS reference standard. They found that there are notable differences in the growth patterns of breastfed infants against the CDC growth charts as was the case when compared to the NCHS reference standard.[22] The study showed that breastfed infants from the pooled sample grow faster than the CDC weight-for-age reference in the first 2 months of life and then less rapidly from 3 - 12 months. The CDC reference standard, like the NCHS reference standard, suggests a faltering in weight gain from 2 months of age which may lead healthcare workers to conclude that the mother's breast milk is insufficient for the growth of the infant. This again may lead to the advancement of formula feeding and early

introduction of complementary feeds. For the length-for-age reference the pattern is similar for the two reference standards except that linear growth faltering in the breastfed sample is delayed by one month when using the CDC reference standard. The investigators then concluded that the CDC growth charts are not suitable for assessing the growth of breastfed infants and that a reference is needed based on breastfed infants if growth patterns are to be assessed.[30]

A second Working Group established in 1995, the WHO Working Group on the Growth Reference Protocol, aimed to develop a protocol for the construction of new growth references. The Working Group's approach was that these references should be a standard of how children should grow and not a description of how they grow in a specific setting. Subsequently, the WHO Multicentre Growth Reference Study (MGRS) was initiated.[25, 31]

1.4.3 The 2006 WHO reference

In April 2006 the WHO released new infant and child growth standards for boys and girls aged 0 - 60 months. These standards were the product of the WHO Multicentre Growth Reference Study (MGRS). The WHO MGRS was conducted from July 1997 to December 2003 to overcome the limitations of the 1977 NCHS reference standard.[31, 32] The study followed the growth of infants and children receiving care according to current recommended health practices. The study combined data from a longitudinal study for infants from birth to 24 months with a cross-sectional study for children aged 18 – 71 months. The growth curves

developed only extend up to 60 months of age but data collection was extended to 71 months to provide reliable estimates of growth at 60 months and thus increasing the precision of the curves. The pooled sample includes infants and children from Brazil, Ghana, Norway, India, Oman and the USA and consisted of approximately 8500 children. The subjects included were healthy children living under optimal conditions to depict how children should grow.[31] A recent study indicated a similarity in linear growth from birth to 5 years in major ethnic groups living under relatively wealthy conditions. This supported the inclusion of all six the above mentioned sites for the development of an international growth reference standard.[33] The mothers enrolled in the longitudinal study followed or were willing to follow recommended health and feeding practices for their children.[31, 32] The mothers were required to comply with the following MGRS recommendations: exclusive or predominant breastfeeding for at least 4 months, introduction of complementary foods by the age of 6 months and partial breastfeeding continued for at least 12 months. No maternal smoking before and after delivery, single term birth, and absence of significant morbidity were other inclusion criteria. The inclusion criteria for the cross-sectional study were the same as those for the longitudinal study except for a minimum of 3 months of breastfeeding required. These reference standards therefore rely on the exclusively and predominantly breast-fed infant as the normative model.[31, 34]

The WHO Child Growth Standards are however only applicable to children aged 0 - 60 months and there was a great need for growth references for older children and adolescents to assess the growing problem of childhood obesity. The WHO then aimed to construct growth curves for school-aged children and adolescents that is in agreement with the WHO under-fives growth references and the BMI cut-offs for adults. In the construction of these growth references data from the 1977 NCHS/WHO growth reference (1 - 24 years) were merged with data from the WHO under-fives growth references' 18 - 71 months cross-sectional sample. The reference includes BMI-for-age (5 - 19 years) -, height-for-age (5 - 19 years) -, and weight-for-age (5 - 10 years) growth charts. The BMI-for-age and height-for-age charts extend to 19 years; the upper age limit of adolescence as defined by the WHO.[35] The weight-for-age charts extend to 10 years to benefit those countries that routinely measure only weight. The BMI-for-age chart is there to complement the height-for-age chart in assessing thinness, stunting, overweight and obesity due to the weight-for-age chart being inappropriate to measure growth after childhood. The WHO reference standard 2007 was published in 2007 and is appropriate for children and adolescents aged 5 - 19 years (61 - 228 months).[36]

Table 1.1: A summary of the main differences between the 1977 NCHS -, 2000 CDC -, and the 2006 WHO reference standards

	1977 NCHS reference standard	2000 CDC reference standard	2006 WHO reference standard
Data base(s) used:	Fels data + NHES cycles I, II + NHANES I	NHES cycles II, III + NHANES I, II, III + birth certificates + Fels data + PedNSS	WHO MGRS
Character-istics of population:	• Caucasian infants • From middle-class society • Predominantly formula-fed • Very few infants were breastfed for > 3 months • Birth weights did not match national weight distributions • Subjects measured every 3 months	• Ethnic distribution of subjects more representative of US at that time • Both formula-fed and breastfed infants included • More closely represent birth weight distribution in the USA	• Infants from Brazil, Ghana, India, Norway, USA • Mothers followed or were willing to follow current WHO feeding recommendations • Infants were exclusively or predominantly breastfed for at least 4 months • Weaning at 6 months

* NHES - National Health Examination Survey

NHANES - National Health and Nutrition Examination Survey

PedNSS - Pediatric Nutrition Surveillance System

MGRS - Multicentre Growth Reference Study

1.5 Motivation for the Study

The motivation for this study stemmed from the fact that the 1977 NCHS reference standard used to analyse the anthropometric data from the 1999 NFCS had several limitations. Considering these limitations, it was anticipated that the reanalyzing the data with the use of the 2000 CDC - and the 2006 WHO reference standards may lead to differences in the previously estimated prevalence of stunting, underweight, wasting, risk of overweight, overweight and obesity in the study population. Such differences, if statistically significant, may have important implications for national nutritional policy construction.

CHAPTER 2: METHODOLOGY

2.1 Research Aims

2.1.1 Aim

The aim was to perform a secondary analysis of anthropometric data from the 1999 National Food Consumption Survey (NFCS) using different reference standards, for South African children 12 - 60 months of age.

2.1.2 Specific objectives

Specific objectives were to:

1. To interpret the anthropometric status of children aged 12 – 60 months using the 2000 CDC - and the 2006 WHO reference standards in terms of the prevalence of the following:

- stunting
- underweight
- wasting
- risk of overweight
- overweight
- obesity

2. To determine if there is a significant difference between the results obtained from the 1977 NCHS -, the 2000 CDC - and the 2006 WHO reference standards.
3. To explore any relationships between anthropometric status and other variables such as the presence of breastfeeding, the level of maternal

education and the type of dwelling as determined by the 2000 CDC - and the 2006 WHO reference standards.

2.2 Hypotheses

2.2.1 Null hypotheses

1. H_0: There is no significant difference between the anthropometric classification of nutritional status of children aged 12 - 60 months using the 1977 NCHS -, 2000 CDC - and the 2006 WHO reference standards.
2. H_0: There is no significant association between anthropometric classification of nutritional status using the 2000 CDC reference standard and the presence of breastfeeding, the level of maternal education and the type of dwelling when compared to the 1977 NCHS reference standard.
3. H_0: There is no significant association between anthropometric classification of nutritional status using the 2006 WHO reference standard and the presence of breastfeeding, the level of maternal education and the type of dwelling compared to the 1977 NCHS reference standard.

2.3 Study Design

A secondary analysis of existing data on children aged 12 - 60 months, from a cross sectional, descriptive, observational national survey.[16]

2.4 Study Population and Sampling

2.4.1 Study population

The study population for this study included all children aged 12 - 60 months in South Africa. The children were selected from the 1999 National Food Consumption Survey database (*N* = 2894). This was a nationally representative sample with provincial representation.[16]

2.4.2 Sampling

The National Food Consumption Survey used the 1996 Census information to select a nationally representative sample with provincial representation.[37] The exact detail of the sampling strategy followed is described elsewhere.[16] Briefly the sampling strategy consisted of 3 stages of which stage 1 was the selection of clusters. Each cluster was defined as an Enumerator area (EA). A total of 156 EA's were stratified for, of which 82 were urban and 74 non-urban. The distribution of EA's per province was proportional to the distribution of the total population and the urban/non-urban distribution within each province.

During the second stage of the sampling strategy a partial sampling frame was set up using an adapted version of “Snowball Sampling”. This entailed random selection of a number of households (HH) in each EA. Each HH was then asked whether there were other HH’s in the area with children in the age range of 12 and 108 months. From this sampling frame the required number of HH’s was then randomly selected.

During the third stage one child per HH was randomly selected to be included in the survey. If there was more than one child present in the HH that qualified, a specially designed “Random Number Table” was used to select only one child to be included.[16]

2.4.3 Sample selection and weighting procedures

The self-weighted minimum sample size of 2200 children was generated in accordance with the population size in the nine provinces, stratified for age, urban and rural residence, and provincial and national representation. However, it was required that there be a minimum of 50 observations per province and per urban/rural strata for the 24 hour recall questionnaire (24-H-RQ). Subsequently, the number of children was increased to 2440. This sample was then adapted by 50% over sampling to account for approximately 25% of children not being at home during the time of the survey and allowing for an overrepresentation of 25% of the children living in low socioeconomic areas. The final sample size was 3120 children. The final sample consisted of 2894 children with a 93% response rate.[16]

It was then necessary to adjust the sample of 2894 children to the total proposed minimum national sample of 2200, by means of weighting in a secondary data analysis. Firstly the base weight was calculated. This is the component of the sample weight that accounts for the differential probabilities of selection. This in turn is defined as the inverse of the inclusion probability of the individual in the sample. The base weights consequently included adjustments for a minimum stratum size of 50 subjects, the requirement that the stratum size had to be a multiple of 20, and over-sampling for high-risk areas.[38]

Calculating final weights involved post-stratification. The post-stratification cells included age categories and known population totals obtained from the 1996 census data. This was performed to adjust the sample weights of the responding subjects so that the totals over various demographic categories matched known population totals. This adjustment provided for sampling frame inadequacies and non-responses. The final totals were then calculated separately for each age group, within each stratum (province, urban versus rural). The final weighted sample consisted of 2200 children.[38]

The results indicated that some under-representation was present in the original 7 to 8 year old age group. This was likely due to some of the children being in school during the time of the survey. Weighting increased the sample size of this group. Furthermore the over-sampled high-risk, low socio-economic groups, found mainly in rural areas and farms decreased. The results showed that the

weighted and non-weighted results were similar in most categories despite the adjustments with 1% to 3% differences in 90% of the categories. More details on the weighting procedure and results have been published elsewhere.[38]

2.5 NFCS Methodology

A detailed description of the methodology followed in the NFCS is described elsewhere.[16] The NFCS developed a quantitative food frequency questionnaire (QFFQ) to determine whether the infant or child was breastfed and a socio-demographic questionnaire to obtain information relating to anthropometry, the type of dwelling the infant or child lived in and the education level of the mother/caregiver.

The following methodological detail from the NFCS is applicable to the current study:

2.5.1 Age and gender determination

The subject's birth date and gender were obtained from the birth certificate or Road to Health Card; if none of these were available it was obtained from the subject's mother / caregiver. The birth year and/or birth month and/or approximate birth date was obtained if the exact birth date could not be determined. A replacement HH was chosen if none of these could be

determined. The age of the subject was defined according to completed years of life consequently only children younger than 108 completed months were included in the survey.[16]

2.5.2 Weight determination

Weight in kilograms was determined using electronic scales and an average of two readings was used. Instructions were presented in a training manual and the methods followed are described elsewhere. When the baby/child was not able to stand alone on the scale, the mother/caregiver was weighed first, then the mother/caregiver together with the baby were weighed and the weight of the mother subtracted.[16]

2.5.3 Length/Height determination

2.5.3.1 *Children younger than 2 years*

The supine length of these children was determined using a measuring board. The average of two readings was reported and the measurement was repeated if the two readings differed by more than 0.5 cm. The detail of the procedure followed is described elsewhere.[16]

2.5.3.2 *Children older than 2 years of age*

The standing height of these children was taken by means of a stadiometer. The average of two readings was taken and the measurement was repeated if the two readings varied by more than 0.5 cm. The exact detail of the procedure

followed is described elsewhere.[16]

2.6 Methods of Data Processing and Statistical Analysis

2.6.1 General

All children 12 - 60 months of age, in South Africa, with a complete set of anthropometric data were included in the analyses for this study. Data for 1512 children were available and were analysed with SAS 9.1 for Windows (SAS Institute, Cary, NC, USA).

Anthropometric data obtained in the 1999 NFCS was entered for analyses using the SAS System (Version 6.12 for Windows) under the supervision of two statisticians to ensure quality control of the data. The data was then compared to those of the 1977 NCHS reference standard using Epi Info Version 6.02 in the 1999 NFCS, which was also used for this survey.[16]

For the purpose of this study the 2000 CDC - and the 2006 WHO reference standards were used to describe the nutritional status and growth of the children.[39, 40] Anthropometric data obtained in the 1999 NFCS were exported from the SAS System (Version 6.12 for Windows) to Microsoft Office Access 2003. Since the 1999 NFCS study the Epi Info version has been upgraded and the data was imported from Microsoft Office Access 2003 to Epi Info 3.4. Consequently the anthropometric status of the children was determined by

comparing the data with those of the 2000 CDC reference standard using Epi Info Version 3.4. The anthropometric data was also compared to those of the 2006 WHO reference standard using the WHO Anthropometric calculator.[41]

A Z-score (the number of standard deviations (SD) from the reference population) was calculated for each child for weight-for-age (W/A), weight-for-length/height (W/H), length/height-for-age (H/A) using each of the 3 reference standards and BMI-for-age using the 2000 CDC - and the 2006 WHO reference standards.

2.6.2 Criteria used for the assessment of anthropometric status

The categorization of the children's anthropometric status used in the NFCS was as follows:

A Z-score of less than minus two standard deviations (< -2 SD) was used to classify low weight-for-age (underweight), low height-for-age (stunting) and low weight-for-height (wasting). Z-scores of greater than plus two standard deviations (> +2 SD) were used to classify a high weight-for-age and weight-for-height.[16]

If the Z-score for weight-for-age or height-for-age was less than -6SDs or greater than +6SDs, or if the Z-score for weight-for-height was less than -4SDs or greater than +6SDs, then the record was verified for accuracy of data entry. Any error upon data entry was corrected but where no error could be detected the entry was excluded from the analysis.[16]

The categorization of the children's anthropometric status using the 2000 CDC reference was as follows: (Table 2.1)

Table 2.1: Categorization of the children's anthropometrical status using the 2000 CDC reference standard

	Growth Indicators			
Z-score	**Length/height -for-age**	**Weight-for-age**	**Weight-for-length/height**	**BMI-for-age**
Above 3 SD	Tallness	Possible growth deviation	Obese	Obese
Above 2 SD	Normal	Possible growth deviation	Overweight	Overweight
Above 1 SD	Normal	Possible growth deviation	Risk of overweight	Risk of overweight
0 (median)	Normal	Normal	Normal	Normal
Below -1 SD	Normal	Normal	Normal	Normal
Below -2 SD	Stunted	Underweight	Wasted	Wasted
Below -3 SD	Severely stunted	Severely underweight	Severely wasted	Severely wasted

Source: From Epi Info Version 3.4

The categorization of the children's anthropometric status using the 2006 WHO reference is shown in Table 2.2.

Table 2.2: Categorization of the children's anthropometric status using the 2006 WHO reference standard

	Growth indicators			
Z-score	**Length/ height-for-age**	**Weight-for-age**	**Weight-for-length/height**	**BMI-for-age**
Above 3 > + 3 SD	Tallness	Possible growth deviation	Obese	Obese
Above 2 >+ 2 SD and ≤ + 3 SD	Normal	Possible growth deviation	Overweight	Overweight
Above 1 > + 1 SD and ≤ + 2SD	Normal	Possible growth deviation	Risk of overweight	Risk of over weight
0 (median)	Normal	Normal	Normal	Normal
Below - 1 < - 1 SD ≥ - 2 SD	Normal	Normal	Normal	Normal
Below - 2 < - 2 SD ≥ - 3 SD	Stunted	Underweight	Wasted	Wasted
Below - 3 < - 3 SD	Severely stunted	Severely underweight	Severely wasted	Severely wasted

Source: From reference[3]

2.6.3 Methods of analysis of anthropometric data

The MEANS procedure of the SAS System was used to determine a mean, Z-score or the number of standard deviations (SD) from the reference population median, and 95% confidence intervals (CI). If the Z-score for weight-for-age or length/height-for-age was < - 6 SD's or > + 6 SD's then the data entry was checked for accuracy. If the Z-score for weight-for-length/height was less than - 4 SD's or greater than + 6 SD's the data entry was verified for accuracy. These extreme Z-scores were excluded from the analysis.

The FREQ Procedure of the SAS System was used to calculate the percentage (%) of children classified as tall, normal, stunted or severely stunted using length/height-for-age Z-scores by means of the three reference standards.

The FREQ Procedure was also used to determine the percentage (%) of children whose weight-for-age Z-scores was possibly deviating, normal, underweight and severely underweight using the three reference standards and to calculate the percentage (%) of children whose weight-for-length/height Z-scores classified them as being obese, overweight, being at risk for overweight, normal, wasted or severely wasted using the three reference standards.

The BMI Z-scores of the children, the percentage (%) of children classified as either obese, overweight, being at risk for overweight, normal, wasted or severely wasted were also calculated.

The FREQ Procedure of the SAS System was used to compile contingency tables and McNemar tests were performed to determine possible associations between the HAZ, WAZ, WHZ and BMIZ of the three reference standards.

Chi - Square tests were performed to determine the differences between the percentages of children classified by each one of the reference standards.

The Bonferroni (Dunn) t-test was used to perform multiple comparison tests to compare variables including the presence of breastfeeding, maternal education level and type of housing.

The MEANS Procedure of the SAS System was used to determine the mean and SD for HAZ, WAZ, WHZ and BMI Z-scores for each of the three reference standards for the different levels of education of the mother, the different types of housing, and the presence of breastfeeding.

2.7 Ethics

2.7.1 Ethics and legal aspects

The research protocol was submitted to and approved by the Human Research Committee of the Faculty of Health Sciences of the University of Stellenbosch (Project Number: N07/03/054). Permission for use of the NFCS data was requested from and approved by the Directors of the NFCS.

2.7.2 Informed consent and patient confidentiality

In the NFCS, each participant had to give written consent in the form of a consent form. Each participant was introduced to the fieldworker and assured of the confidentiality of the information collected during the interview.[16]

During this study confidentiality was ensured at all times by not revealing the names of the participants.

CHAPTER 3: RESULTS

3.1 Sample Characteristics

The data collection period for the 1999 NFCS was between February and July 1999. The survey population consisted of South African children aged 12 - 108 months. Of the 3120 subjects 93% responded and the final sample consisted of 2894 children. This was a nationally representative sample with provincial representation.[16]

The study population for this study was selected from the NFCS database and included all children younger than 60 months of age with a complete set of anthropometric information, in South Africa. Of these 1382 children were excluded due to incomplete/incorrect data entries. The total number of children included in the analysis was then 1512, 5% of the original sample. Of the sample of 1512 children, 798 (52.8%) were male and 714 (47.2%) were female. The mean age of the sample was 3.0 years (SD 1.15), the mean age of the males were 2.9 years (SD 1.13) and the mean age of the females was 3.0 years (SD 1.17).

3.2 Prevalence and Significant Differences between the References

The 2006 WHO reference standard significantly overestimated the mean Z-scores of length/height-for-age (-1.2 > -1.0, -0.9) (SD 1.53), weight-for-length/height (0.4 > 0.1, 0.1) (SD 1.24) and BMI-for-age (0.6 > 0.2) (SD 1.29) and significantly underestimated weight-for-age (-0.4 < -0.6, -0.6) (SD 1.18) compared to the 1977 NCHS and the 2000 CDC reference standards ($p < 0.0001$) (Figure 3.1)

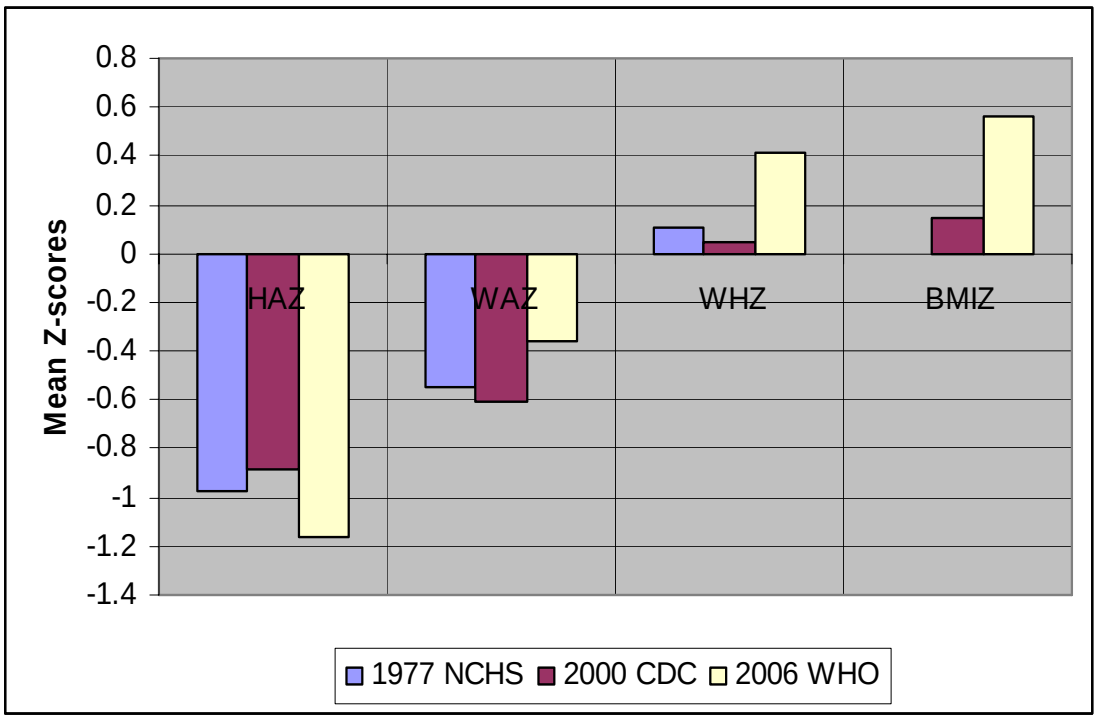


Figure 3.1: Comparison of the mean HAZ, WAZ, WHZ and BMIZ using the different reference standards in this study

3.2.1 Stunting

The mean percentages of children aged 12- 60 months, classified as having a normal length/height for their age were 74.7% (*N* = 1130), 78.9% (*N* = 1193) and 69.4% (*N* = 1050) for the 1977 NCHS -, 2000 CDC - and the 2006 WHO reference standards respectively (Figure 3.2). The 2006 WHO reference standard classified a significantly lower percentage of the study population to have a normal length/height-for-age (Chi - Square p < 0.0001). The 2006 WHO reference standard classified 20.1% (*N* = 304) of the children as being stunted which was significantly higher than the NCHS 1977 reference standard at 17.1% (*N* = 259) and the 2000 CDC reference standard at 14.2% (*N* = 215)

(Chi - Square p < 0.0001).

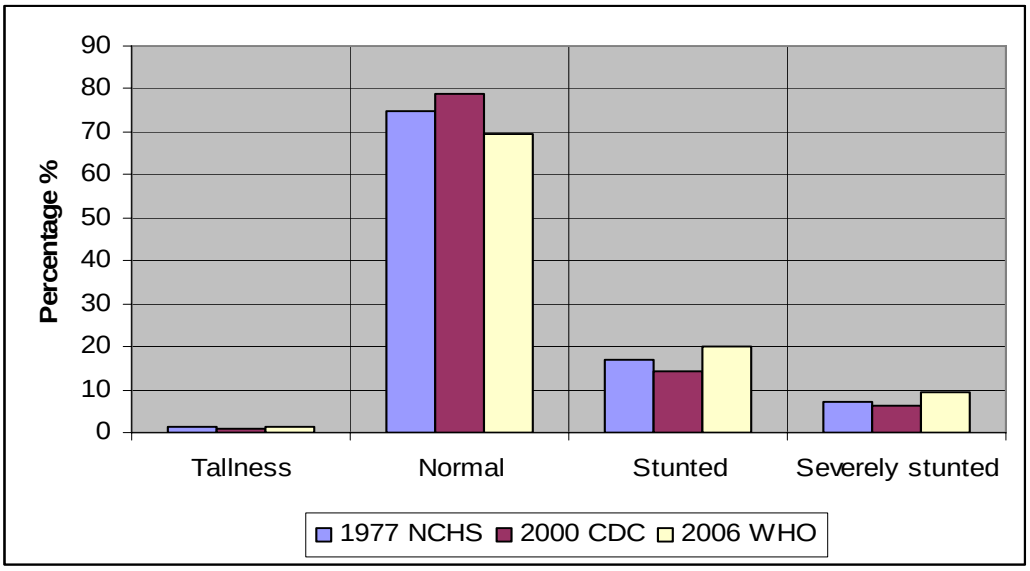


Figure 3.2: Percentage of children aged 12 - 60 months classified for length/height-for-age by the 1977 NCHS -, 2000 CDC - and 2006 WHO reference standards

3.2.1.1 *Comparison between the 1977 NCHS - and the 2006 WHO reference standards*

The McNemar test was performed to determine a possible association between the 1977 NCHS - and the 2006 WHO reference standards. A significant relationship ($p < 0.0001$) was found between the two reference standards with very few cases of misclassification; both reference standards classified 1.1% (*N* = 16) of the children as tall, 69.3% (*N* = 1047) of the children as having a normal length/height-for-age, 14.7% (*N* = 222) of the children as being stunted and 6.9% (*N* = 105) of the children as being severely stunted (Table 3.1). However, 5.4% (*N* = 82) of the children was misclassified as normal length/height-for-age by the 1977 NCHS reference standard and stunted by the 2006 WHO reference standard. Similarly, 2.4% (*N* = 36) of the children were misclassified as stunted by the NCHS reference standard and severely stunted by the WHO reference standard (see yellow highlighted area).

Table 3.1: Percentages of children classified for length/height-for-age by the 1977 NCHS and the 2006 WHO reference standards

		2006 WHO reference standard			
		Tallness	Normal	Stunted	Severely stunted
		Frequency Percent (%)	Frequency Percent (%)	Frequency Percent (%)	Frequency Percent (%)
1977 NCHS reference standard	Tallness	16 (1.06%)	2 (0.13%)	0	0
	Normal	1 (0.07%)	1047 (69.25%)	82 (5.42%)	0
	Stunted	0	1 (0.07%)	222 (14.68%)	36 (2.38%)
	Severely stunted	0	0	0	105 (6.94%)

*** McNemar Test p < 0.0001**

3.2.1.2 *Comparison between the 1977 NCHS - and the 2000 CDC reference standards*

Similarly the McNemar test showed a significant association ($p < 0.0001$) between the 1977 NCHS - and the 2000 CDC reference standards (Table 3.2). Together both references classified 0.8% ($N = 12$) of the children aged 12 - 60 months as tall, 74.5% ($N = 1127$) of the children as having a normal length/height-for-age, 12.8% ($N = 194$) as stunted and 5.7% ($N = 86$) as severely stunted.

On the other hand, 4.0% (*N* = 60) of the children were misclassified as stunted by the NCHS reference standard and normal length/height-for-age by the CDC reference standard (see yellow highlighted area).

Table 3.2: Percentages of children classified for length/height-for-age by the 1977 NCHS and the 2000 CDC reference standards

		2000 CDC reference standard			
		Tallness	Normal	Stunted	Severely stunted
		Frequency Percent (%)	Frequency Percent (%)	Frequency Percent (%)	Frequency Percent (%)
1977 NCHS reference standard	Tallness	12 (0.79%)	6 (0.40%)	0	0
	Normal	1 (0.07%)	1127 (74.54%)	2 (0.13%)	0
	Stunted	0	60 (3.97%)	194 (12.83%)	5 (0.33%)
	Severely stunted	0	0	19 (1.26%)	86 (5.69%)

*** McNemar Test p < 0.0001**

3.2.1.3 Comparison between the 2000 CDC - and the 2006 WHO reference standards

The McNemar test indicated a significant association ($p < 0.0001$) between the 2000 CDC - and the 2006 WHO reference standards (Table 3.3). Both reference standards classified 0.9% (*N* = 13) of the children as being tall, 69.4% (*N* = 1050) as having a normal length/height for their age, 10.9% (*N* = 165) as being stunted and 6.0% (*N* = 91) as being severely stunted, but 9.2% (*N* = 139) of the children were classified as stunted by the WHO reference standard and normal length/height-for-age by the CDC reference (see yellow highlighted areas)

Table 3.3: Percentages of children classified for length/height-for-age by the 2000 CDC and the 2006 WHO reference standards

		2000 CDC reference standard			
		Tallness	Normal	Stunted	Severely stunted
		Frequency Percent (%)	Frequency Percent (%)	Frequency Percent (%)	Frequency Percent (%)
2006 WHO reference standard	Tallness	13 (0.86%)	4 (0.26%)	0	0
	Normal	0	1050 (69.44%)	0	0
	Stunted	0	139 (9.19%)	165 (10.91%)	0
	Severely stunted	0	0	50 (3.31%)	91 (6.02%)

*** McNemar Test p < 0.0001**

3.2.2 Underweight

On analysis of the weight-for-age Z-scores of children aged 12 - 60 months, the 1977 NCHS reference standard classified 58.5% (*N* = 884) of the children as having a normal weight for their age which was significantly higher (Chi - Square $p < 0.0001$) than the 2000 CDC reference standard at 55.0% (*N* = 831) and the 2006 WHO reference standard at 56.1% (*N* = 848). (Figure 3.3) The 2006 WHO reference standard found 6.8% (*N* = 103) of the sample population to be underweight for their age which was significantly lower than the 1977 NCHS - and the 2000 CDC reference standards at 9.7% (*N* = 146) and 9.9% (*N* = 150) respectively (Chi - Square $p < 0.0001$).

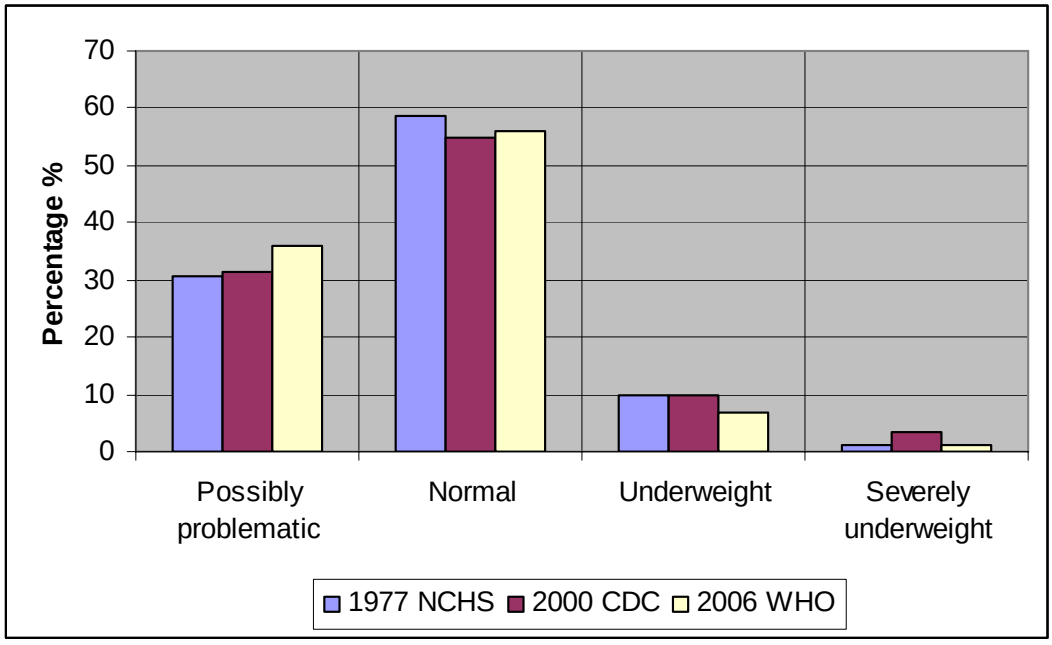


Figure 3.3: Percentage of children aged 12 - 60 months classified for weight-for-age by the 1977 NCHS -, 2000 CDC - and the 2006 WHO reference standards

3.2.2.1 *Comparison between the 1977 NCHS - and the 2006 WHO reference standards*

The McNemar test indicated a significant association ($p < 0.0001$) between the 1977 NCHS - and the 2006 WHO reference standards (Table 3.4). Both reference standards classified 30.1% (*N* = 455) of the children to have a possibly problematic weight for their age, 52.5% (*N* = 793) of the children were found to be at a normal weight for their age and 0.9% (*N* = 14) of the children were classified as being severely underweight. Ninety-one (6.0%) children were misclassified as having a normal weight-for-age by the NCHS reference standard and a possibly problematic weight by the WHO reference standard. Forty-five (3.0%) children were misclassified by the NCHS reference standard as underweight and as having a normal weight-for-age by the WHO reference standard (see yellow highlighted areas).

Table 3.4: Percentages of children classified for weight-for-age by the 1977 NCHS and the 2006 WHO reference standards

		2006 WHO reference standard			
		Weight possibly problematic	Normal	Underweight	Severely underweight
		Frequency Percent (%)	Frequency Percent (%)	Frequency Percent (%)	Frequency Percent (%)
1977 NCHS reference standard	Weight possibly problematic	455 (30.09%)	10 (0.66%)	0	0
	Normal	91 (6.02%)	793 (52.45%)	0	0
	Underweight	0	45 (2.98%)	100 (6.61%)	1 (0.07%)
	Severely underweight	0	0	3 (0.20%)	14 (0.93%)

*** McNemar Test p < 0.0001**

3.2.2.2 *Comparison between the 1977 NCHS - and the 2000 CDC reference standards*

The McNemar Test indicated a significant relationship ($p < 0.0001$) when comparing the 1977 NCHS - and the 2000 CDC reference standards (Table 3.5). Both references classified 29.2% (*N* = 441) of the sample population as having a possibly problematic weight for their age, 53.4% (*N* = 807) to have a normal weight for their age, 7.2% (*N* = 109) to be underweight and 1.1% (*N* = 17) to be

severely underweight. However, 2.4% (*N* = 36) of the sample population were classified as having a normal weight-for-age by the NCHS reference standard but having a possibly problematic weight-for-age by the CDC reference standard. Also, 41 children (2.7%) were classified as having a normal weight-for-age by the NCHS reference standard but being underweight by the CDC reference standard (see yellow highlighted areas)

Table 3.5: Percentages of children classified for weight-for-age by the 1977 NCHS and the 2000 CDC reference standards

		2000 CDC reference standard			
		Weight possibly problematic	Normal	Underweight	Severely underweight
		Frequency Percent (%)	Frequency Percent (%)	Frequency Percent (%)	Frequency Percent (%)
1977 NCHS reference standard	Weight possibly problematic	441 (29.17%)	24 (1.59%)	0	0
	Normal	36 (2.38%)	807 (53.37%)	41 (2.71%)	0
	Underweight	0	0	109 (7.21%)	37 (2.45%)
	Severely underweight	0	0	0	17 (1.12%)

*** McNemar Test p < 0.0001**

3.2.2.3 *Comparison between the 2000 CDC - and the 2006 WHO reference standards*

When performing the McNemar test, a significant relationship ($p < 0.0001$) was shown between the 2006 WHO and the 2000 CDC reference standards (Table 3.6). Both reference standards classified 49.3% (*N* = 745) of the children in this age group to have a normal weight-for-age and 4.4% (*N* = 66) to be underweight. However, 5.7% (*N* = 86) of the sample population were misclassified by the WHO reference standard as having a possibly problematic weight and having a normal weight-for-age by the CDC reference standard (see yellow highlighted area).

Table 3.6: Percentages of children classified for weight-for-age by the 2000 CDC and the 2006 WHO reference standards

		2000 CDC reference standard			
		Weight possibly problematic	Normal	Underweight	Severely underweight
		Frequency Percent (%)	Frequency Percent (%)	Frequency Percent (%)	Frequency Percent (%)
2006 WHO reference standard	Weight possibly problematic	460 (30.42%)	86 (5.69%)	0	0
	Normal	17 (1.12%)	745 (49.27%)	84 (5.56%)	2 (0.13%)
	Underweight	0	0	66 (4.37%)	37 (2.45%)
	Severely underweight	0	0	0	15 (0.99%)

*** McNemar Test p < 0.0001**

3.2.3 Classification of wasting, risk of overweight, overweight and obesity

3.2.3.1 Weight-for-length/height

Using the weight-for-length/height *Z*-scores, 5.9% (*N* = 89) of the study population were classified as being obese by the 1977 NCHS reference standard compared to 6.3% (*N* = 95) and 9.5% (*N* = 144) by the 2000 CDC - and the 2006 WHO reference standards respectively. The WHO reference standard found

20.6% (*N* = 312) of the children to be overweight which was significantly higher when compared to the other reference standards (Chi Square p < 0.0001). The 1977 NCHS and the 2000 CDC reference standards classified 13.0% (*N* = 197) and 16.7% (*N* = 253) of the children as being overweight respectively. The 2006 WHO - and the 1977 NCHS reference standards produced a similar classification of children as being at risk of overweight at 33.2% (*N* = 502) and 33.3% (*N* = 503) respectively. In comparison the 2000 CDC reference standard also classified 30.5% (*N* = 461) of the children as being at risk of overweight. According to the 1977 NCHS reference standard, 30.4% (*N* = 459) of the children have a normal weight for their length/height. The 2006 WHO reference standard found 24.3% (*N* = 367) and the 2000 CDC reference standard found 25.5% (*N* = 386) of the children to be at a normal weight for their length/height. The percentage of children classified as wasted were found to be similar for the 1977 NCHS - and the 2000 CDC reference at 15.0% (*N* = 226). However, the 2006 WHO reference found only 10.0% (*N* = 151) of the children to be wasted which was significantly lower than the other reference standards (Chi Square p < 0.0001).

a) ***Comparison between the 1977 NCHS - and the 2006 WHO reference standards***

The McNemar test showed a significant association (p < 0.0001) between the 1977 NCHS -and the 2006 WHO reference standards (Table 3.7). Both references found 5.9% (*N* = 89) of the children be obese, 9.3% (*N* = 140) were

overweight, 18.6% (*N* = 281) to be at a normal weight-for-length/height and 9.4% (*N* = 142) were classified as wasted. On the other hand, 176 children (11.6%) were misclassified by the NCHS reference standard as having a normal weight-for-length/height and by the WHO as being at risk of overweight and 81 children (5.4%) were misclassified as normal weight-for-length/height by the WHO reference standard and wasted by the NCHS reference standard (see yellow highlighted areas).

Table 3.7: Percentages of children classified for weight-for-length/height by the 1977 NCHS and the 2006 WHO reference standards

		2006 WHO reference standard					
		Obese	Over-weight	Risk of over-weight	Normal	Wasted	Severely wasted
		Freq Percent (%)	Freq Percent (%)	Freq Percent (%)	Freq Percent (%)	Freq Percent (%)	Freq Percent (%)
1977 NCHS refe-rence standard	Obese	89 (5.89%)	0	0	0	0	0
	Over-weight	55 (3.64%)	140 (9.26%)	2 (0.13%)	0	0	0
	Risk of over-weight	0	172 (11.38%)	325 (21.49%)	5 (0.33%)	0	0
	Normal	0	0	176 (11.64%)	281 (18.58%)	2 (0.13%)	0

Table 3.7: Percentages of children classified for weight-for-length/height by the 1977 NCHS and the 2006 WHO reference standards (Continued)

	Wasted	**0**	**0**	**0**	**81 (5.36%)**	**142 (9.39%)**	**3 (0.20%)**
	Severely wasted	**0**	**0**	**0**	**0**	**7 (0.46%)**	**32 (2.12%)**

*** McNemar Test p < 0.0001**

**** Freq - Frequency**

b) ***Comparison between the 1977 NCHS - and the 2000 CDC reference standard***

Upon performing the McNemar test a significant relationship ($p < 0.0001$) was shown between the 1977 NCHS - and the 2000 CDC reference standards (Table 3.8). 4.9% (*N* = 74), 11.2% (*N* = 169), 24.3% (*N* = 368) and 11.2% (*N* = 169) were classified by both references as obese, overweight, normal weight-for-length/height and wasted respectively. Again there was misclassification of children; the NCHS reference standard classified 69 (4.6%) of the children to at risk of overweight and the CDC reference standard classified them as overweight. Also, 57 (3.8%) children were classified as normal weight-for-length/height by the NCHS reference standard and as wasted by the CDC reference standard (see yellow highlighted areas).

Table 3.8: Percentages of children classified for weight-for-length/height by the 1977 NCHS and the 2000 CDC reference standards

		2000 CDC reference standard					
		Obese	Over-weight	Risk of over-weight	Normal	Wasted	Sever-ely wasted
		Freq Percent (%)	Freq Percent (%)	Freq Percent (%)	Freq Percent (%)	Freq Percent (%)	Freq Percent (%)
1977 NCHS refer-ence stan-dard	Obese	74 (4.89%)	15 (0.99%)	0	0	0	0
	Over-weight	21 (1.39%)	169 (11.18 %)	7 (0.46%)	0	0	0
	Risk of over-weight	0	69 (4.56%)	420 (27.78 %)	13 (0.86%)	0	0
	Normal	0	0	34 (2.25%)	368 (24.34 %)	57 (3.77%)	0
	Wasted	0	0	0	5 (0.33%)	169 (11.18 %)	52 (3.44%)
	Sever-ely wasted	0	0	0	0	0	39 (2.58%)

*** McNemar Test p < 0.0001**

**** Freq - Frequency**

c) *Comparison between the 2000 CDC - and the 2006 WHO reference standards*

The McNemar test again indicated a significant association ($p < 0.0001$) between the weight-for-length/height classifications by the 2000 CDC - and the 2006 WHO reference standards (Table 3.9). Both reference standards grouped 6.3% (*N* = 95) of the children as being obese, 13.5% (*N* = 204) as overweight, 15.5% (*N* = 234) as normal weight-for-length/height and 6.3% (*N* = 95) as wasted. The WHO reference standard classified 108 (7.1%) children as overweight but the CDC reference standard classified them as at risk of overweight. One-hundred-and-fifty-two (10.1%) children were classified as at risk of overweight and normal weight-for-length/height by the WHO reference standard and the CDC reference respectively. Similarly, 131 (8.7%) children were classified by the WHO reference standard as normal weight-for-length/height but by the CDC reference standard as wasted (see yellow highlighted areas).

Table 3.9: Percentages of children classified for weight-for-length/height by the 2000 CDC and the 2006 WHO reference standards

		2000 CDC reference standard					
		Obese	Over-weight	Risk of over-weight	Normal	Wasted	Severely wasted
		Freq Percent (%)	Freq Percent (%)	Freq Percent (%)	Freq Percent (%)	Freq Percent (%)	Freq Percent (%)
2006 WHO refe-rence stan-dard	Obese	95 (6.28%)	49 (3.24%)	0	0	0	0
	Over-weight	0	204 (13.49%)	108 (7.14%)	0	0	0
	Risk of Over-weight	0	0	351 (23.21%)	152 (10.05 %)	0	0
	Normal	0	0	2 (0.13%)	234 (15.48 %)	131 (8.66%)	0
	Wasted	0	0	0	0	95 (6.28%)	56 (3.70%)
	Seve-rely wasted	0	0	0	0	0	35 (2.31%)

*** McNemar Test p < 0.0001**

**** Freq - Frequency**

3.2.3.2 BMI-for-age

The 2006 WHO reference standard significantly overestimated the percentage of children to be obese, overweight, at risk of being overweight and having a normal BMI-for-age and significantly underestimated the percentage of children to be wasted and severely wasted when compared to the 2000 CDC reference standard (Chi Square $p < 0.0001$).

a) ***Comparison between the 2000 CDC - and the 2006 WHO reference standards***

The 2000 CDC - and the 2006 WHO reference standards were found to be significantly associated ($p < 0.0001$) upon using the McNemar test (Table 3.10). Both reference standards classified 5.8% (*N* = 66) of the children to be obese, 16.4% (*N* = 187) overweight, 15.5% (*N* = 176) to have a normal BMI-for-age and 4.8% (*N* = 54) were wasted. However, 38 (3.3%) children were classified as obese and overweight by the WHO and CDC reference standards respectively and 61 children (5.4%) were classified as overweight and at risk of being overweight by the WHO and CDC reference standards respectively. Eighty-two (7.2%) children were classified as at risk of being overweight by the WHO reference standard but having a normal BMI-for-age by the CDC reference standard and 100 children (8.8%) were classified as normal by the WHO reference standard but as wasted by the CDC reference standard.

Table 3.10: Percentages of children classified for BMI-for-age by the 2000 CDC and the 2006 WHO reference standards

		2000 CDC reference standard					
		Obese	Over-weight	Risk of Over-weight	Normal	Wasted	Severely wasted
		Freq Percent (%)	Freq Percent (%)	Freq Percent (%)	Freq Percent (%)	Freq Percent (%)	Freq Percent (%)
2006 WHO refe-rence standard	Obese	66 (5.80%)	38 (3.34%)	0	0	0	0
	Over-weight	0	187 (16.43%)	61 (5.36%)	0	0	0
	Risk of Over-weight	0	3 (0.26%)	303 (26.63%)	82 (7.21%)	0	0
	Normal	0	0	2 (0.18%)	176 (15.47%)	100 (8.79%)	0
	Wasted	0	0	0	0	54 (4.75%)	46 (4.04%)
	Severely wasted	0	0	0	0	0	20 (1.76%)

* McNemar Test p < 0.0001

** Freq - Frequency

3.3 Relationships between Anthropometric Status and Other Variables

3.3.1 Breastfeeding

3.3.1.1 *Length/height-for-age*

No significant relationship was shown between breastfeeding and length/height-for-age when using any one of the three reference standards (Bonferroni p > 0.05) (Table 3.11).

Table 3.11: Mean HAZ by the 1977 NCHS -, 2000 CDC - and the 2006 WHO reference standards according to the presence of breastfeeding

Breastfeeding status	Breastfeeding Status - Yes	Breastfeeding Status - No	Breastfeeding Status – Not known
Reference	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI
1977 NCHS reference standard	1268 -0.99 (1.48) -1.07 - -0.91 A*	186 -0.86 (1.52) -1.08 - -0.64 A	17 -0.90 (1.36) -1.60 - 0.19 A

Table 3.11: Mean HAZ by the 1977 NCHS -, 2000 CDC - and the 2006 WHO reference standards according to the presence of breastfeeding (Continued)

2000 CDC reference standard	1268 -0.90 (1.44) -0.98 - -0.82 A*	186 -0.77 (1.47) -0.98 - 0.55 A	17 -0.81 (1.33) -1.49 - -0.12 A
2006 WHO reference standard	1268 -1.18 (1.52) -1.27 - -1.10 A*	186 -1.05 (1.57) -1.27 - -0.82 A	17 -1.11 (1.35) -1.81 - -0.41 A

*** Means with the same letter are not significantly different, Bonferroni Multiple Comparison test, p > 0.05.**

3.3.1.2 *Weight-for-age*

Again, no significant relationship was shown between breastfeeding and weight-for-age when using any one of the three reference standards (Bonferroni p > 0.05) (Table 3.12).

Table 3.12: Mean WAZ by the 1977 NCHS -, 2000 CDC - and the 2006 WHO reference standards according to the presence of breastfeeding

Breastfeeding status	Breastfeeding Status - Yes	Breastfeeding Status - No	Breastfeeding Status - Not known
Reference	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI
1977 NCHS reference standard	1268 -0.57 (1.23) -0.64 - -0.50 A*	186 -0.36 (1.33) -0.55 - -0.17 A	17 -0.89 (1.10) -1.45 - -0.33 A
2000 CDC reference standard	1268 -0.63 (1.29) -0.70 - 0.56 A*	186 -0.42 (1.35) -0.62 - -0.22 A	17 -0.95 (1.30) -1.62 - -0.28 A
2006 WHO reference standard	1268 -0.38 (1.17) -0.45 - 0.32 A*	186 -0.18 (1.24) -0.36 - -0.00 A	17 -0.71 (1.07) -1.26 - -0.16 A

*** Means with the same letter are not significantly different, Bonferroni Multiple Comparison test, p > 0.05.**

3.3.1.3 *Weight-for-length/height*

A significant relationship was shown between breastfeeding and weight-for-length/height when using the 1977 NCHS reference standard (Bonferroni $p < 0.05$). The mean WHZ of those infants who were not breastfed differed significantly from those whose breastfeeding status was not known but did not differ significantly from those who were breastfed. (Table 3.13)

Similar results were obtained when using the 2000 CDC and the 2006 WHO reference standards.

Table 3.13: Mean WHZ by the 1977 NCHS -, 2000 CDC - and the 2006 WHO reference standards according to the presence of breastfeeding

Breastfeeding status	Breastfeeding Status - Yes	Breastfeeding Status - No	Breastfeeding Status - Not known
Reference	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI
1977 NCHS reference standard	1268 0.09 (1.18) 0.03 - 0.16 AB*	186 0.27 (1.25) 0.09 - 0.45 A	17 -0.38 (1.02) -0.90 - 0.14 B

Table 3.13: Mean WHZ by the 1977 NCHS -, 2000 CDC - and the 2006 WHO reference standards according to the presence of breastfeeding (Continued)

	1268	186	17
2000 CDC	0.04	0.21	-0.54
reference	(1.31)	(1.36)	(1.27)
standard	-0.04 - 0.11	0.02 - 0.41	-1.19 - 0.11
	AB*	A	B
	1268	186	17
2006 WHO	0.40	0.56	-0.10
reference	(1.23)	(1.29)	(1.12)
standard	0.33 - 0.46	0.37 - 0.75	-0.68 - 0.48
	AB*	A	B

*** Means with different letters are significantly different, Bonferroni Multiple Comparison test, $p < 0.05$.**

3.3.1.4 *BMI-for-age*

No significant relationship was shown between breastfeeding and BMI-for-age when using the 2000 CDC reference standard, however, a significant relationship was illustrated when using the 2006 WHO reference standard. The mean BMIZ of infants who were not breastfed differed significantly (Bonferroni $p < 0.05$) from those whose breastfeeding status were not known, but did not differ significantly from those infants who were breastfed (Bonferroni $p > 0.05$) (Table 3.14).

Table 3.14: Mean BMIZ by the 2000 CDC - and the 2006 WHO reference standards according to the presence of breastfeeding

Breastfeeding status	Breastfeeding Status - Yes	Breastfeeding Status - No	Breastfeeding Status - Not known
Reference	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI
2000 CDC reference standard	968 0.15 (1.27) 0.07 - 0.23 A*	141 0.23 (1.35) 0.01 - 0.45 A	14 -0.37 (1.38) -1.16 - 0.43 A
2006 WHO reference standard	1268 0.54 (1.28) 0.47 - 0.61 AB**	186 0.69 (1.33) 0.50 - 0.88 A	17 0.00 (1.14) -0.58 - 0.59 B

*** Means with similar letters are not significantly different, Bonferroni Multiple Comparison test, p > 0.05**

**** Means with different letters are significantly different, Bonferroni Multiple Comparison test, p < 0.05**

3.3.2 Maternal education level

3.3.2.1 *Length/height-for-age*

A significant relationship was shown between maternal education level and length/height-for-age when using any of the three references (Bonferroni $p < 0.05$).

The 1977 NCHS, 2000 CDC and 2006 WHO reference standards illustrated a significant difference between the mean length/height-for-age Z-scores of children from mothers with tertiary education and the rest of the levels of education (Bonferroni $p < 0.05$) (Table 3.15). The mean HAZ of children from mothers with no -, std 6 - 8 -, std 9 - 10 -, and those whose education level was not known did not differ significantly from each other. However, all the mean Z-scores of the children, irrespective of maternal education level were above – 2 SD.

Table 3.15: Mean HAZ by the 1977 NCHS -, 2000 CDC - and the 2006 WHO reference standards according to the education level of the mother

Education levels	No education	Primary education	Std 6-8 education	Std 9-10 education	Tertiary education	Education level not known
Reference	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI
1977 NCHS reference standard	123 -1.18 (1.55) -1.46 – -0.91 BC*	359 -1.32 (1.44) -1.47 – -1.17 C	421 -0.97 (1.50) -1.11 – -0.82 BC	377 -0.78 (1.45) -0.93 – -0.64 B	95 -0.20 (1.34) -0.47 - 0.07 A	64 -0.91 (1.41) -1.26 – -0.56 BC
2000 CDC reference standard	123 -1.09 (1.48) -1.36 – -0.83 BC*	359 -1.21 (1.41) -1.36 – -1.06 C	421 -0.87 (1.47) -1.01 – -0.73 BC	377 -0.70 (1.39) -0.84 – -0.56 B	95 -0.12 (1.27) -0.38 - 0.13 A	64 -0.83 (1.36) -1.17 – -0.50 BC
2006 WHO reference standard	123 -1.39 (1.54) -1.67 – -1.12 BC*	359 -1.52 (1.48) -1.67 – -1.36 C	421 -1.16 (1.55) -1.31 – -1.01 BC	377 -0.97 (1.48) -1.12 – -0.82 B	95 -0.36 (1.36) -0.64 – -0.08 A	64 -1.15 (1.43) -1.50 – -0.79 BC

*** Means with different letters are significantly different, Bonferroni Multiple Comparison test, $p < 0.05$**

3.3.2.2 *Weight-for-age*

The 1977 NCHS and the 2000 CDC reference standards indicated that the mean weight-for-age Z-scores of children from mothers with tertiary education differed significantly from the other levels of education (Bonferroni $p < 0.05$), and the other levels of maternal education did not differ significantly from each other (Table 3.16).

The 2006 WHO reference standard indicated a significant difference between the mean WAZ of children from mothers with tertiary education compared to the other levels of education (Bonferroni $p < 0.05$).

Table 3.16: Mean WAZ by the 1977 NCHS -, 2000 CDC - and the 2006 WHO reference standards according to the education level of the mother

Education levels	No education	Primary education	Std 6-8 education	Std 9-10 education	Tertiary education	Education level not known
Reference	***N*** **Mean Z-score (SD) 95% CI**	***N*** **Mean Z-score (SD) 95% CI**	***N*** **Mean Z-score (SD) 95% CI**	***N*** **Mean Z-score (SD) 95% CI**	***N*** **Mean Z-score (SD) 95% CI**	***N*** **Mean Z-score (SD) 95% CI**
1977 NCHS reference	**123 -0.76 (1.27) -0.99 – -0.53 B***	**359 -0.81 (1.24) -0.94 – -0.68 B**	**421 -0.52 (1.26) -0.64 – -0.40 B**	**377 -0.42 (1.18) -0.54 – -0.30 B**	**95 0.07 (1.25) -0.18 - 0.33 A**	**64 -0.61 (1.10) -0.88 – -0.33 B**
2000 CDC reference	**123 -0.84 (1.32) -1.08 – -0.61 B***	**359 -0.88 (1.34) -1.02 – -0.74 B**	**421 -0.58 (1.32) -0.71 – -0.45 B**	**377 -0.47 (1.19) -0.59 – -0.35 B**	**95 0.02 (1.21) -0.22 - 0.27 A**	**64 -0.62 (1.17) -0.91 – -0.33 B**
2006 WHO reference	**123 -0.61 (1.18) -0.82 – -0.40 C***	**359 -0.63 (1.18) -0.75 – -0.50 C**	**421 -0.32 (1.19) -0.44 – -0.21 BC**	**377 -0.21 (1.10) -0.32 – -0.09 B**	**95 0.25 (1.15) 0.02 - 0.49 A**	**64 -0.43 (1.04) -0.69 – -0.17 BC**

*** Means with different letters are significantly different, Bonferroni Multiple Comparison test, $p < 0.05$**

3.3.2.3 *Weight-for-length/height*

No significant differences were found between the mean weight-for-length/height Z-scores of the different maternal education levels when using any one of the three reference standards (Bonferroni p > 0.05) (Table 3.17).

Table 3.17: Mean WHZ by the 1977 NCHS -, 2000 CDC - and the 2006 WHO reference standards according to the education level of the mother

Education level	No education	Primary education	Std 6-8 education	Std 9-10 education	Tertiary education	Education level not known
Reference	***N*** **Mean Z-score (SD) 95% CI**	***N*** **Mean Z-score (SD) 95% CI**	***N*** **Mean Z-score (SD) 95% CI**	***N*** **Mean Z-score (SD) 95% CI**	***N*** **Mean Z-score (SD) 95% CI**	***N*** **Mean Z-score (SD) 95% CI**
1977 NCHS reference standard	**123 -0.00 (1.23) -0.23 - 0.21 A***	**359 0.03 (1.23) -0.10 - 0.15 A**	**421 0.15 (1.21) 0.03 - 0.26 A**	**377 0.15 (1.15) 0.03 - 0.26 A**	**95 0.36 (1.20) 0.11 - 0.60 A**	**64 0.00 (1.04) -0.26 - 0.26 A**
2000 CDC reference standard	**123 -0.12 (1.33) -0.36 - 0.11 A***	**359 -0.04 (1.37) -0.18 - 0.10 A**	**421 0.10 (1.36) -0.03 - 0.23 A**	**377 0.10 (1.26) -0.02 - 0.23 A**	**95 0.30 (1.27) 0.04 - 0.56 A**	**64 -0.07 (1.23) -0.37 - 0.24 A**

Table 3.17: Mean WHZ by the 1977 NCHS -, 2000 CDC - and the 2006 WHO reference standards according to the education level of the mother (Continued)

2006 WHO reference standard	**123** **0.26** **(1.24)** **0.04 - 0.48** **A***	**359** **0.33** **(1.29)** **0.20 - 0.46** **A**	**421** **0.46** **(1.27)** **0.33 - 0.58** **A**	**377** **0.45** **(1.18)** **0.33 - 0.57** **A**	**95** **0.62** **(1.20)** **0.38 - 0.86** **A**	**64** **0.30** **(1.12)** **0.02 - 0.58** **A**

*** Means with similar letters are not significantly different, Bonferroni Multiple Comparison test, p > 0.05**

3.3.2.4 *BMI-for-age*

Using the Bonferroni (Dunn) t-test, no significant differences were found between the mean BMI-for-age Z-scores of the different education levels using the 2000 CDC - and the 2006 WHO reference standards (Bonferroni p > 0.05) (Table 3.18).

Table 3.18: Mean BMIZ by the 2000 CDC - and the 2006 WHO reference standards according to the education level of the mother

Education level	No education	Primary education	Std 6-8 education	Std 9-10 education	Tertiary education	Education level not known
Reference	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI
2000 CDC reference standard	103 -0.02 (1.27) -0.27 - 0.23 A*	275 0.16 (1.31) -0.00 - 0.31 A	315 0.22 (1.29) 0.08 - 0.37 A	267 0.14 (1.27) -0.01 - 0.30 A	66 0.17 (1.21) -0.13 - 0.46 A	56 -0.06 (1.28) -0.40 - 0.28 A
2006 WHO reference standard	123 0.41 (1.29) 0.18 - 0.64 A*	359 0.51 (1.33) 0.37 - 0.65 A	421 0.60 (1.33) 0.47 - 0.73 A	377 0.58 (1.25) 0.46 - 0.71 A	95 0.68 (1.25) 0.43 - 0.94 A	64 0.43 (1.18) 0.14 - 0.73 A

*** Means with similar letters are not significantly different, Bonferroni Multiple Comparison test, P > 0.05**

3.3.3 Type of housing

3.3.3.1 *Length/height-for-age*

No significant differences were found, when performing the Bonferroni t-test, between the mean Z-scores of the different types of housing indicating no relationship between type of housing and length/height-for-age when using any one of the three reference standards (Bonferroni $p > 0.05$) (Table 3.19).

Table 3.19: Mean HAZ by the 1977 NCHS -, 2000 CDC - and the 2006 WHO reference standards according to the type of dwelling

Type of housing	Brick	Traditional mud	Tin	Plank/wood	Other materials
Reference	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI
1977 NCHS reference standard	982 -0.86 (1.50) -0.95 – -0.76 A*	238 -1.23 (1.50) -1.42 – -1.04 A	214 -1.18 (1.33) -1.36 – -1.00 A	31 -0.86 (1.67) -1.50 – -0.27 A	27 -0.83 (1.53) -1.43 – -0.23 A

Table 3.19: Mean HAZ by the 1977 NCHS -, 2000 CDC - and the 2006 WHO reference standards according to the type of dwelling (Continued)

2000 CDC reference standard	982 -0.77 (1.45) -0.86 – -0.68 A	238 -1.3 (1.45) -1.31 – -0.94 A	214 -1.09 (1.29) -1.26 – -0.92 A	31 -0.80 (1.68) -1.41 – -0.18 A	27 -0.75 (1.53) -1.36 – -0.15 A
2006 WHO reference standard	982 -1.05 (1.53) -1.15 – -0.96 A	238 -1.41 (1.52) -1.61 – -1.22 A	214 -1.38 (1.38) -1.57 – -1.20 A	31 -1.07 (1.78) -1.73 – -0.42 A	27 -1.04 (1.60) -1.67 – -0.41 A

*** Means with similar letters are not significantly different, Bonferroni Multiple Comparison test, P > 0.05**

3.3.3.2 *Weight-for-age*

Using the Bonferroni multiple comparison test, no significant differences were found between the mean weight-for-age Z-scores using the 1977 NCHS -, 2000 CDC - and the 2006 WHO reference standards (Bonferroni p > 0.05). This implies no relationship was found between the type of housing and weight-for-age (Table 3.20).

Table 3.20: Mean WAZ by the 1977 NCHS -, 2000 CDC - and the 2006 WHO reference standards according to the type of dwelling

Type of housing	Brick	Traditional mud	Tin	Plank/wood	Other materials
Reference	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI
1977 NCHS reference standard	982 -0.49 (1.28) -0.57 – -0.41 A*	238 -0.62 (1.19) -0.77 – -0.47 A	214 -0.69 (1.15) -0.84 – -0.53 A	31 -0.51 (1.22) -0.95 – -0.06 A	27 -0.98 (1.50) -1.57 – -0.39 A
2000 CDC reference standard	982 -0.30 (1.20) -0.38 – -0.23 A	238 -0.43 (1.15) -0.58 – -0.28 A	214 -0.46 (1.11) -0.61 – -0.31 A	31 -0.32 (1.13) -0.73 – .09 A	27 -0.83 (1.46) -1.41 – -0.26 A
2006 WHO reference standard	982 -0.55 (1.32) -0.63 – -0.46 A	238 -0.67 (1.25) -0.83 – .51 A	214 -0.74 (1.23) -0.91 – -0.58 A	31 -0.52 (1.23) -0.98 – -0.07 A	27 -1.13 (1.76) -1.83 – -0.43 A

*** Means with similar letters are not significantly different, Bonferroni Multiple Comparison test, P > 0.05**

3.3.3.3 *Weight-for-length/height*

By means of the Bonferroni (Dunn) t-test, a significant difference was shown between the mean weight-for-length/height Z-scores for the type of dwellings; the mean WHZ of those individuals living in homes constructed of other materials than what was listed in the 1999 NFCS differed significantly from the other types of dwellings when using any one of the three reference standards (Bonferroni $p < 0.05$) (Table 3.21).

Table 3.21: Mean WHZ by the 1977 NCHS -, 2000 CDC - and the 2006 WHO reference standards according to the type of dwelling

Type of housing	Brick	Traditional mud	Tin	Plank/wood	Other materials
Reference	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI	*N* Mean Z-score (SD) 95% CI
1977 NCHS reference standard	982 0.11 (1.21) 0.03 - 0.19 A	238 0.20 (1.20) 0.05 - 0.36 A	214 0.08 (1.17) -0.08 - 0.24 A	31 0.11 (0.88) -0.22 - 0.43 A	27 -0.53 (1.27) -1.03 – -0.03 B*

Table 3.21: Mean WHZ by the 1977 NCHS -, 2000 CDC - and the 2006 WHO reference standards according to the type of dwelling (Continued)

2000 CDC reference standard	982 0.04 (1.33) -0.04 - 0.12 A	238 0.17 (1.34) -0.00 - 0.34 A	214 0.05 (1.30) -0.12 - 0.23 A	31 0.10 (1.00) -0.27 - 0.46 A	27 -0.81 (1.61) -1.45 – -0.17 B*
2006 WHO reference standard	982 0.40 (1.25) 0.33 - 0.48 A	238 0.51 (1.25) 0.35 - 0.67 A	214 0.42 (1.22) 0.26 - 0.59 A	31 0.43 (0.95) 0.08 - 0.77 A	27 -0.35 (1.32) -0.88 - 0.17 B*

*** Means with different letters are significantly different, Bonferroni Multiple Comparison test,**

P < 0.05

3.3.3.4 *BMI-for-age*

The Bonferroni (Dunn) t-test showed that the mean BMI-for-age Z-score of children living in homes made of other materials than what was listed in the 1999 NFCS differed significantly from the rest of the types of homes when using the 2000 CDC reference standard (Bonferroni $p < 0.05$) (Table 3.22).

But using the 2006 WHO reference standard it was indicated that children living in homes made of other materials than what was listed by the 1999 NFCS differed significantly (Bonferroni $p < 0.05$) from the rest of the types of homes but did not differ significantly from those of children living in brick homes (Bonferroni $p > 0.05$).

Table 3.22: Mean BMIZ by the 2000 CDC - and the 2006 WHO reference standards according to the type of dwelling

Type of housing	Brick	Traditional mud	Tin	Plank	Other materials
Reference	Means (SD) 95% CI	Means (SD) 95% CI	Means (SD) 95% CI	Means (SD) 95% CI	Means (SD) 95% CI
2000 CDC reference standard	745 0.13 (1.30) 0.03 - 0.22 A**	178 0.22 (1.23) 0.04 - 0.41 A	154 0.21 (1.28) 0.01 - 0.42 A	25 0.36 (0.97) -0.04 - 0.76 A	24 -0.57 (1.47) -1.19 - 0.05 B*
2006 WHO reference standard	982 0.53 (1.29) 0.45 - 0.61 AB	238 0.68 (1.31) 0.51 - 0.85 A	214 0.60 (1.29) 0.43 - 0.78 A	31 0.57 (0.97) 0.21 - 0.92 A	27 -0.23 (1.36) -0.77 - 0.30 B*

*** Means with different letters are significantly different, Bonferroni Multiple Comparison test, P < 0.05**

**** Means with similar letters are not significantly different, Bonferroni Multiple Comparison test, P > 0.05**

CHAPTER 4: DISCUSSION

4.1 Introduction

Overcoming malnutrition is a major obstacle to countries worldwide, but especially for Africa. The consequences of malnutrition are widespread and influence every facet of an individual's life ranging from impaired intellectual development and poor school performance and even mortality for children; to poor work performance, reproductive problems and chronic disease in adulthood. Growth assessment is important to evaluate the nutritional status of an individual or entire population to determine the health of individuals and the quality of life of the population. Growth assessment also enables health care workers and national policy-makers to plan, implement, manage and evaluate nutrition intervention programmes. Reference standards such as the 1977 NCHS -, 2000 CDC - and 2006 WHO reference standards enable health care workers to evaluate an individual's or population's nutritional status by comparing their anthropometric indices to the references.[23]

Currently the WHO recommends the use of the 2006 WHO reference standard to assess the growth and development of children worldwide.

The 1999 National Food Consumption Survey (NFCS) undertook the major task of determining the nutritional status of children aged 1 - 9 years in South Africa. The anthropometric data collected in the national survey were analysed by means of the 1977 NCHS reference.[16] Considering the limitations of this reference standard as discussed elsewhere, it was anticipated that the use of the

2000 CDC - and the 2006 WHO reference standard may lead to differences in the previously estimated prevalence of stunting, wasting, underweight, risk of overweight, overweight and obesity in the South African study population. Such differences, if statistically significant, will have an important implication for national nutritional policy construction. The possible relationship between anthropometric classification of nutritional status and other variables was also explored. These variables included breastfeeding, the education level of the mother and the type of dwelling. Any relationships between nutritional status and the other variables may provide important information for health educators and policy makers in their goal to improve the nutritional status of infants and children. Consequently the anthropometric data from the 1999 NFCS was reanalysed by the 2000 CDC and the 2006 WHO reference standards.

4.2 Results from this Survey

The results of this secondary analysis of the 1999 National Food Consumption Survey in South Africa showed significant differences in the classification of nutritional status and growth of children when using the 2006 WHO and the 2000 CDC - as compared to the 1977 NCHS reference standards.

4.2.1 Prevalence of stunting, wasting, underweight, risk of overweight, overweight and obesity

The 2006 WHO reference standard classified a significantly lower percentage of the study population to have a normal height-for-age and a significantly higher percentage as stunted when compared to the 2000 CDC and 1977 NCHS reference standards. This is in agreement with recent reports by de Onis *et al*. (2006). The latter study was a secondary analysis of longitudinal data from Bangladesh, Dominican Republic and a pooled sample of infants from North America and Northern Europe. The study reported increased stunting rates for all age groups when using the WHO reference standard compared to the 1977 NCHS reference standard. These differences are likely due to the WHO reference standard including only exclusively and predominantly breastfed infants, infants fed according to current WHO feeding guidelines, and the predominantly formula fed sample of the NCHS reference standard. Another reason could be the differences in measurement intervals between the two references and the prescriptive approach followed by the WHO reference standard.[42] Another study by de Onis *et al*. (2006) used data from a pooled sample of healthy breastfed infants from Northern Europe and North America to evaluate the adequacy of the CDC and WHO reference standards for assessing the growth of breastfed infants. The results showed that stunting rates will be higher when using the 2006 WHO - compared to the 2000 CDC reference standard. Possible explanations are the prescriptive rather than descriptive approach of the WHO reference standard and the standardization of the

measurements in the study population and the multiple datasets used to construct the CDC reference standard.[43]

The 2000 CDC height-for-age reference estimated the prevalence of stunting to be significantly lower (14.22%) than the 1977 NCHS reference standard (17.13%) in the study population. This is in agreement with a study by Kuczmarski *et al*. (2002) which reported the difference in the prevalence of stunting when comparing the 1977 NCHS - to the 2000 CDC reference standard. The results stated that the prevalence of stunting will be lower when using the 2000 CDC reference standard compared to the 1977 NCHS reference standard. This may be due to the 2000 CDC length-for-age curves generally being lower than the 1977 NCHS curves, especially after 6 months of age and consequently more children will have a low height-for-age.[26]

Using the 2006 WHO reference standard the prevalence of stunting was significantly higher than previously estimated by the 1999 NFCS using the 1977 NCHS reference standard. The 1999 NFCS reported stunting to be the most common nutritional disorder at the national level affecting one in five children in South Africa and the children least affected were those living in urban areas.[16]

The 2006 WHO weight-for-age reference standard classified a significantly lower percentage of the children as underweight (6.81%) compared to the 1977 NCHS and the 2000 CDC reference standards. This too agrees with recent literature

from de Onis *et al*. (2006). The investigators from the latter study reported that the sample of healthy breastfed infants appeared to falter on the NCHS weight-for-age reference from 2 months onwards. The results also showed increased underweight rates during the first 6 months of life and then lower underweight rates thereafter when using the 2006 WHO reference standard compared to the 1977 NCHS reference standard. This may have resulted from the 2006 WHO reference's population being exclusively and predominantly breastfed and the population of the 1977 NCHS reference standard being predominantly formula-fed. The growth of breastfed infants and children differ significantly from formula-fed infants. Exclusively breastfed infants' weight gain decreases from 2 months of age resulting in weight-for-age curves that are lower than the curves of the NCHS and CDC reference standards. Consequently fewer infants and children are classified as underweight when the 2006 WHO reference standard is used.[42] The study by de Onis *et al*. (2006) agrees that lower rates of under nutrition will result after the first 6 months of life when based on the WHO reference standard compared to the 2000 CDC reference standard.[43] The 2000 CDC weight-for-age reference found a slightly higher percentage of the children to be underweight compared to the 1977 NCHS reference standard at 9.92% and 9.66% respectively. This finding is similar to Kuczmarski *et al*. (2002) which stated that the prevalence of underweight will be higher when using the 2000 CDC reference standard compared to the 1977 NCHS reference standard. This may be due to the 2000 CDC percentiles being higher than the corresponding 1977 NCHS reference from approximately 12 to 24 months for weight-for-age.[26] The 1999

NFCS reported that one in ten children aged 1 - 9 years are underweight at the national level.[16]

Similarly the prevalence of wasting was significantly lower when using the 2006 WHO weight-for-height reference at 9.99% compared to the other 2 reference standards both at 14.95%. This is not in agreement with the recent study by de Onis *et al*. (2006) which showed that during the first 6 months of life the prevalences of wasting using the WHO reference standard was 2.5 times those estimated by the NCHS reference standard and the pattern continued afterwards but was only slightly higher from the second year to 5 years of age.[42] However, another study by de Onis *et al*. (2006) stated that the estimates of wasting and severe wasting will decrease from 70 cm onward when using the WHO weight-for-height reference compared to the CDC reference standard.[43] A possible explanation could be the linear growth and weight gain of breastfed infants being lower and slower than formula-fed infants after 6 months of age. Consequently the 2006 WHO weight-for-height reference curve is lower than the others and fewer children are classified as wasted.

In contrast, the 2006 WHO weight-for-height reference classified a significantly higher percentage of the children to be obese and overweight compared to the NCHS reference standard. De Onis *et al.* (2006) similarly reported a higher prevalence of children being overweight when using the 2006 WHO - compared to the 1977 NCHS reference standard and also recommends the 2006 WHO

reference standard for screening overweight throughout childhood.[42] The differences are likely again due to the inclusion of the predominantly breastfed infant in the WHO reference standard and the predominantly formula-fed infant in the 1977 NCHS reference standard. Differences in measurement intervals also play a role; infants were measured every 2 weeks in the first two months and then monthly thereafter in the WHO reference standard and in the NCHS reference standard the infants were measured every 3 months. The latter may not be sufficient to describe the rapid growth of an infant and child. The WHO reference standard is also based on a prescriptive approach and indicates how children should grow and the NCHS reference standard is a standard of how children were growing.[42] De Onis *et al*. (2006) compared the 2006 WHO - to the 2000 CDC reference standard and also agreed that higher rates of overweight and obesity will result when using the WHO reference standard.[43] The 2000 CDC reference standard classified 6.28% of the population to be obese and 16.73% to be overweight which was significantly higher than the percentages by the 1977 NCHS reference standard, 30.49% were found to be at risk of overweight which was significantly lower than the 1977 NCHS reference standard and 14.95% to be wasted which was identical to the 1977 NCHS reference standard. This may have resulted from the weight-for-length curves, for lengths ranging from approximately 50 to 70 cm, of the 2000 CDC reference standard being higher than the 1977 NCHS curves.[26]

The 1977 NCHS reference standard does not enable evaluation of nutritional status by BMI-for-age in pre-school children thus a comparison could only be drawn between the 2000 CDC and the 2006 WHO reference standards. Comparison between the 2000 CDC and the 2006 WHO reference standards showed the prevalences of obesity, overweight and risk of being overweight were significantly higher when using the 2006 WHO BMI-for-age reference standard. This is in agreement with a recent study by de Onis *et al*. (2006) also stating higher prevalence of overweight and obesity will result and lower prevalence of under nutrition when the WHO BMI-for-age reference is used.[43] The prevalence of wasting in this study was however significantly higher when using the 2000 CDC reference standard. Again this may be due to the weight gain and linear growth of exclusively breastfed infants differing substantially from formula-fed infants. Since the 2006 WHO reference standard is based on predominantly breastfed infants it is expected that the prevalence of wasting will be lower since their linear growth and weight gain is lower than those of formula-fed infants.

Wasting was less prevalent in the NFCS and affected one out of twenty children. The prevalence of overweight was higher in urban areas (7.5%) than the national average (6%). In the formal urban areas one in thirteen children was found to be overweight; the prevalence of which was higher in educated mothers.[16]

4.2.2 Anthropometric status related to other variables

4.2.2.1 *Breastfeeding*

No significant relationship was shown between breastfeeding and height-for-age and weight-for-age when using any one of the three reference standards. However, a significant relationship was shown between breastfeeding and weight-for-height when using any one of the three reference standards. No significant relationship was illustrated between breastfeeding and BMI-for-age when using the CDC reference standard, but a significant association was shown when using the WHO BMI-for-age reference standard.

The mean height-for-age Z-scores of those infants who were not breastfed was the closest to the median when using any of the three references indicating a nutritional status that is better than the other subjects. This may have resulted due to the age of the sample population. The study population were children aged 12 - 60 months at which age most children are no longer breastfed or only partially breastfed and other variables influence their nutritional status such as the nutritional quality of complementary foods, the socio-economic status of the household, sanitation and disease.

Those infants whose breastfeeding status was not known by their present caregivers had the poorest nutritional status in terms of weight-for-age when using any one of the three reference standards. The feeding history of these children was not known. Those infants who were not breastfed had the best

mean weight for their age. Again this may be due to the slower weight gain of infants and children who were breastfed when compared to formula fed infants. Consequently more breastfed children were classified as being underweight. Also it may be related to the age range of the sample population; at 12 - 60 months children have been weaned and complementary foods introduced. These foods may be of poor nutritional quality and consequently influence nutritional status. However, none of these differences were significant.

A significant relationship was shown between breastfeeding and weight-for-height when using any one of the three reference standards. Children who were breastfed had a mean weight-for-height Z-score closest to the median, implying a better nutritional status than the other, when using the 1977 NCHS and the 2000 CDC reference standards. However, this mean Z-score did not differ significantly from the Z-scores of children who were not breastfed. Using the 2006 WHO reference standard it was indicated that the mean weight-for-height Z-scores of children whose breastfeeding status was not known by their present caregivers, was the closest to the median but did not differ significantly from those who were breastfed.

Using the 2000 CDC BMI-for-age reference standard no significant relationship was indicated between breastfeeding and BMI-for-age. It was also indicated that those infants who were breastfed had the mean Z-score closest to the median; however the Z-score did not differ significantly from the Z-scores of children who

were not breastfed and whose breastfeeding status was not known by their present caregivers. A possible reason for this could be that the sample population used to construct the 2000 CDC curves were based on predominantly formula-fed infants and the sample population of the WHO reference standard were exclusively and predominantly breastfed thus taking into consideration the growth and development of breastfed children. Also, the WHO BMI-for-age reference starts at birth but only at 2 years of age using the CDC BMI-for-age reference implying that children of 2 years of age are no longer breastfed.[43] The 2006 WHO reference standard on the other hand, indicated that those infants whose breastfeeding status was not known by their present caregivers had the best mean BMIZ, but this Z-score did not differ significantly from those who were breastfed.

At the time of the NFCS only one out of ten children of all ages at the national level were still being breastfed and 19% (one out of five) of children 1 - 3 years was still being breastfed. However 63% of children at the national level had been breastfed for more than a year in contrast to 5% of all children receiving infant formulae at the time of the survey. Artificial infant feedings were more prevalent in ages 1 - 3 years. Infant formulae use was equally common in rural and urban areas.[16]

Clearly, a relationship exists between breastfeeding and the growth and nutritional status of infants and children.

4.2.2.2 *Maternal education level*

The socio-demographic data from the 1999 NFCS showed that one out of ten mothers of children of all age groups had no formal education, three out of four mothers had attained some level of education with 25% having primary school only and 27% high school and 8% tertiary education. The study also showed that maternal education was an important determinant for nutritional status; improved maternal education was associated with a significant reduction in the prevalence of stunting, wasting and underweight.[16]

This study also illustrated a significant relationship between height-for-age and the mother's level of education when using any one of the three reference standards. The mean HAZ of children whose mothers had tertiary education differed significantly from the other levels and was closest to the median when using the 1977 NCHS, 2000 CDC and 2006 WHO reference standards, implying that by educating the mother, the child will have improved nutritional status. This is consistent with a report from Ivanovic (1997) performed in Chile, which states that the degree of food and nutrition knowledge is significantly and positively correlated with the mother's education level.[18] Possible reasons for this could be that an increase in the mother's education level will imply an improvement in the level of occupation and consequently socio-economic status. An improved socio-economic status also implies greater financial means to purchase a variety of foods of good nutritional quality. Mamabolo *et al.* (2004) performed a study in Limpopo, South Africa, evaluating the feeding practices and growth patterns of

infants in this area. Stunting became increasingly apparent in the early months when using the 1977 NCHS reference standard and remained high for the 12 month period of the study. Factors such as the mother's level of education, employment status, parity and access to electricity were reported as influencing the pattern of stunting.[44]

A significant association was illustrated between weight-for-age and the level of maternal education when using any one of the three reference standards. A significant difference was found between the mean weight-for-age Z-scores of children whose mothers have tertiary education and the rest of the education levels when using the 1977 NCHS and the 2000 CDC reference standards. However, the mean Z-scores of the remaining education levels did not differ significantly from each other. But, when using the 2006 WHO reference standard it was shown that the mean Z-scores of children from mothers with tertiary education also differed significantly from the rest and that the remaining levels of education differed significantly from each other. The mean Z-scores of children from mothers with no education, primary education only, standard 6 - 8, std 9 - 10, and those whose education level was not known did not differ significantly from each other but from the children from mothers with tertiary education.

No significant relationship was demonstrated between weight-for-height and the mother's education level. This could be due to the fact that the weight-for-height reference incorporates both weight and height implying that even if a child was

thin he would not be classified as malnourished if his height coincided with the weight.

No significant relationship was demonstrated between BMI-for-age and maternal education level when using the 2000 CDC and 2006 WHO reference standards. Both references indicated that children from mothers with no education had the mean Z-score closest to the median, showing a normal nutritional status, however the differences between the levels of education was not significant.

4.2.2.3 *Type of dwelling*

The NFCS reported that at a national level 67% of all children lived in dwellings constructed with bricks or cement. The remainder of the survey population lived in traditional homes or homes made of tin, plank/wood or other material. The 1999 NFCS, using the 1977 NCHS reference standard, also reported that children in all age groups living in brick or concrete homes had the lowest overall prevalence of stunting, but in general there was no pattern of a significant association between the type of dwelling and the prevalence of stunting, underweight or wasting.[16] This study also indicated no significant relationship between the type of housing the children lived in and their height-for-age and weight-for-age when using any one of the three reference standards.

On the other hand a significant relationship was shown between weight-for-height and the type of building materials used to construct a home when using

any one of the three reference standards. Using the 1977 NCHS and 2000 CDC reference standards it was clear that children living in homes constructed of other materials than what was listed in the NFCS had the poorest mean weight-for-height Z-score. The 2006 WHO reference standard showed that children living in homes made of tin had the poorest mean Z-score. Other materials that could be used could include grass and plastic. Those materials and the tin used to make a home indicate poor socio-economic status and housing conditions. The study by Ivanovic (1997) reported that the degree of food and nutrition knowledge is significantly and positively correlated with the housing conditions. The poorer the housing conditions the poorer the nutritional status.[18] The mean WHZ of those children living in homes constructed of other materials than what was listed in the NFCS differed significantly from the other types of dwellings when using any one of the three reference standards.

A significant relationship was shown between the type of housing and BMI-for-age. In using the 2000 CDC - and 2006 WHO reference standards a significant difference was found between the mean BMIZ of those children living in homes constructed of other materials than listed by the NFCS and the rest of the type of dwellings. However, the mean BMIZ of children living in homes of “other” materials did not differ significantly from those living in brick homes when using the 2006 WHO reference standard.

A recent study by Mamabolo *et al.* (2005) also reported a link between housing conditions and nutritional status stating that living in a household with nine or more persons was a risk factor for being stunted.[45]

4.3 Implications of Results for Programmes and Policies

The results obtained from this study differed from those reported by the 1999 NFCS when making use of the 2000 CDC and the 2006 WHO reference standards to analyse the anthropometric data. The NFCS reported that stunting is the most common nutritional disorder while it is evident from this study that being overweight is the most common problem when using the 2006 WHO reference standard. However, the percentage of children classified as overweight is only slightly higher than the percentage of children classified as stunted at 20.63% and 20.11% respectively. This study also showed that the prevalence of stunting is significantly higher when using the 2006 WHO reference standard compared to the 1977 NCHS reference standard.

These results have important implications for The Department of Health and healthcare workers. In developing countries the focus of nutrition intervention programmes are often treating under nutrition whilst it is imperative not to disregard over nutrition as it is evident from this study and recent literature by Mamabolo *et al.* (2005). The study by Mamabolo *et al*. (2005), performed in the Limpopo region of South Africa, reported a high prevalence of both stunting

(48%) and overweight (22%) in 3-year-old children highlighting the importance of evaluating anthropometric status in terms of both under nutrition and over nutrition.[45]

The 1999 NFCS reported that 63% of children at the national level had been breastfed for more than a year in contrast to 5% of all children receiving infant formulae at the time of the survey. Artificial infant feedings were more prevalent in ages 1 - 3 years. Infant formulae use was equally common in rural and urban areas.[16] A study by Faber (2005) reported that the nutrient composition of complementary foods among rural South African infants were inadequate.[46] Consequently strategies must be developed to promote, support and protect the rate of exclusive breastfeeding and to improve the nutritional quality of complementary diets. Advice should be given regarding correct weaning practices and the appropriate age to start weaning.

Currently South Africa uses the Road to Health Chart (RtHC) for evaluating the nutritional status of infants and children. The chart was developed by health professionals from provincial health departments and the national Directorates for Nutrition, Child & Youth Health. The chart is issued at birth and contains information such as a growth monitoring chart, health and demographic information and a health worker consultation sheet. The growth monitoring chart is based on the 1977 NCHS weight-for-age reference standard. This weight-for-age growth chart is used as the reference curve to assess the growth of infants

and children in South Africa.[47] However, it is evident from this study and other studies previously mentioned that the 1977 NCHS reference standard is inadequate for evaluating the nutritional status of infants and children. Currently The Department of Health of South Africa is busy incorporating the 2006 WHO reference standard into the South African growth chart to adopt one standard for evaluating the nutritional status of infants and children.

4.4 Limitations of the study

The limitations of this study relate to the age of the sample population studied. This was mainly due to the age range used in the 1999 NFCS of 1 - 9 years and the age limit of the 2006 WHO reference of 0 - 60 months. Consequently only children aged 12 - 60 months were included in the survey.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion and Recommendations

During the 1999 NFCS the 1977 NCHS reference standard was used to evaluate the anthropometric status of children aged 1 - 9 years in South Africa. However the 1977 NCHS reference standard has several limitations as discussed elsewhere and other references were available to assess nutritional status.[28] It was then anticipated that the estimated prevalence of stunting, wasting, underweight, overweight, risk of overweight and obesity in South African children would differ when using the 2000 CDC - and the 2006 WHO reference standards.

The reanalysis of the anthropometric data with the 2006 WHO reference standard, showed that overweight is the major nutritional problem facing South African children aged 12 - 60 months with stunting following closely. Also, the prevalence of stunting was significantly higher than previously established by the 1977 NCHS reference standard in the 1999 NFCS; the problem of stunting in South Africa is more severe than previously believed. However, the prevalence of underweight and wasting was lower and the prevalence of obesity and overweight was higher when using the 2006 WHO reference standard.

This study also showed no significant relationship between breastfeeding and height-for-age and weight-for-age when using any one of the three reference standards. However, a significant relationship was shown between breastfeeding and weight-for-height when using any one of the three reference standards. No

significant relationship was illustrated between breastfeeding and BMI-for-age when using the 2000 CDC reference standard, but a significant association was shown when using the 2006 WHO BMI-for-age reference standard.

A significant relationship was illustrated between height-for-age and weight-for-age and the mother's level of education when using any one of the three reference standards, however no significant relationship was demonstrated between weight-for-height and the mother's education level and between BMI-for-age and maternal education level.

No significant association was found between the type of housing the children lived in and their height-for-age and their weight-for-age when using any one of the three reference standards. On the other hand a significant relationship was shown between weight-for-height and the type of building materials used to construct a home when using any one of the three reference standards. In each case weight-for-height was lowest for children living in traditional mud houses and houses made from other materials than what was listed in the 1999 NFCS, indicating a tendency of lower weight in children living in informal structures.

These results indicate that national nutrition intervention programmes should not only target under nutrition but also over nutrition, breastfeeding promotion, education and adequate housing conditions. The higher than previously established prevalence of stunting poses a major challenge to South African policy makers and healthcare workers pressurising them to implement nutrition

programmes and evaluate and manage current programmes to decrease the prevalence of stunting. The Integrated Nutrition Programme (INP) is one of the key strategic health programmes in South Africa aiming to decrease morbidity and mortality rates by improving the nutritional status of individuals and the population. The continuation of the INP must be ensured to promote exclusive breastfeeding in all children until six months of age, the appropriate introduction of complementary foods and continuation of breastfeeding until 24 months of age. Other aims of the programme supported by the investigator are ensuring optimal growth of infants and young children, promoting the health of women especially pregnant and lactating women, improving inter-sectoral collaboration and community ownership of nutrition programmes.[48]

Growth monitoring of infants and children should be optimized and at risk individuals must be identified early and managed. Currently South Africa uses the Road to Health Chart (RtHC) for this purpose for all infants and children visiting primary health care clinics. The chart is issued at birth and contains information such as a growth monitoring chart, health and demographic information and a health worker consultation sheet. Currently the growth monitoring chart is based on the 1977 NCHS weight-for-age reference standard. This weight-for-age growth chart is used as the reference curve to assess the growth of infants and children in South Africa, but The Department of Health is in the process of improving the chart to include the 2006 WHO reference standard.[47]

National nutrition intervention programmes promoting prudent dietary guidelines must be implemented and current programmes should be managed to order to reduce the high prevalence of overweight among children.

From a socio-economic point of view, health care professionals are encouraged to promote exclusive breastfeeding up to 6 months of age, unless otherwise contraindicated, unless otherwise contraindicated. Breastfeeding should be continued until 24 months old and advice should be given on appropriate complementary foods. Parents should be provided with complete and current information on the benefits and techniques of breastfeeding. Policies and practices that promote, protect and support breastfeeding should be optimized in order to improve the nutritional status of infants and children in South Africa.

The significant relationship between the education level of the mother and the nutritional status of the infant or child encourages the development of national programmes that educate mothers and caregivers on infant and child nutrition; both under and over nutrition.

The significant relationship between the type of housing and the weight-for-height of an infant or child promotes the fact that poverty stricken households must be identified and referred to one of the government's poverty alleviation programmes to address household food security and to consequently improve nutritional status.

Infectious diseases and micronutrient malnutrition affecting the nutritional status of children must be correctly managed to consequently decrease the prevalence of malnutrition.

In conclusion, the 2006 WHO reference standard used the exclusively and predominantly breastfed infant and child as the normative model and provides a prescription of how children across the world should grow allowing healthcare workers to know whether a child's nutritional needs are met. These reference standards help achieve the Millennium Development Goals by ensuring the proper growth and development of children and identifying unhealthy trends in the population.

The 2006 WHO reference standard is recommended by de Onis *et al.* (2006) for screening overweight throughout childhood and by the World Health Organization as the preferred tool to evaluate the nutritional status of infants and children. It is also endorsed by the International Pediatric Association, the International Union of Nutrition Science and the Standing Committee on Nutrition of the United Nations System.[42, 49, 50, 51]

The Department of Health is currently in the process of changing the Road to Health chart to include this reference. The 2006 WHO reference must be used as the sole reference standard to evaluate the nutritional status of infants and children.

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